DOE/NASA/0180-2
NASA CR-165477

(NASA-CR-165477) MARKET ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS FOR AGRICULTURAL APPLICATIONS I[illegible]OCCO Final Report (DHR, Inc.) 157 p HC A08/MF A01 CSCL 10A

N82-14627

Unclas
G3/44 06243

Market Assessment of Photovoltaic Power Systems for Agricultural Applications in Morocco

Henry Steingass
DHR, Incorporated

and

Itil Asmon
ARD, Incorporated

September 1981

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewis Research Center
Under Contract DEN 3-180

for
U.S. DEPARTMENT OF ENERGY
Conservation and Renewable Energy
Division of Photovoltaic Energy Systems

DOE/NASA/0180-2
NASA CR-165477

Market Assessment of Photovoltaic Power Systems for Argricultural Applications in Morocco

Henry Steingass
DHR, Incorporated
Washington, D.C.

and

Itil Asmon
ARD, Incorporated
Burlington, Vermont

September 1981

Prepared for
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135
Under Contract DEN 3-180

for
U.S. DEPARTMENT OF ENERGY
Conservation and Renewable Energy
Division of Photovoltaic Energy Systems
Washington, D.C. 20545
Under Interagency Agreement DE-AI01-79ET20485

ACKNOWLEDGEMENTS

The study team wishes to express its thanks to the many Moroccan officials, equipment distributors and farmers who cooperated in providing the information on which this report is based. Special thanks are due to Mr. Mark Ward, USAID/Rabat Program Officer, who was extremely helpful in facilitating the team's activities in Morocco.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DC - direct current

KV - kilovolt

KVA - kilovolt-ampere

KW - kilowatt

KWH - kilowatt hour

KWp - kilowatt peak

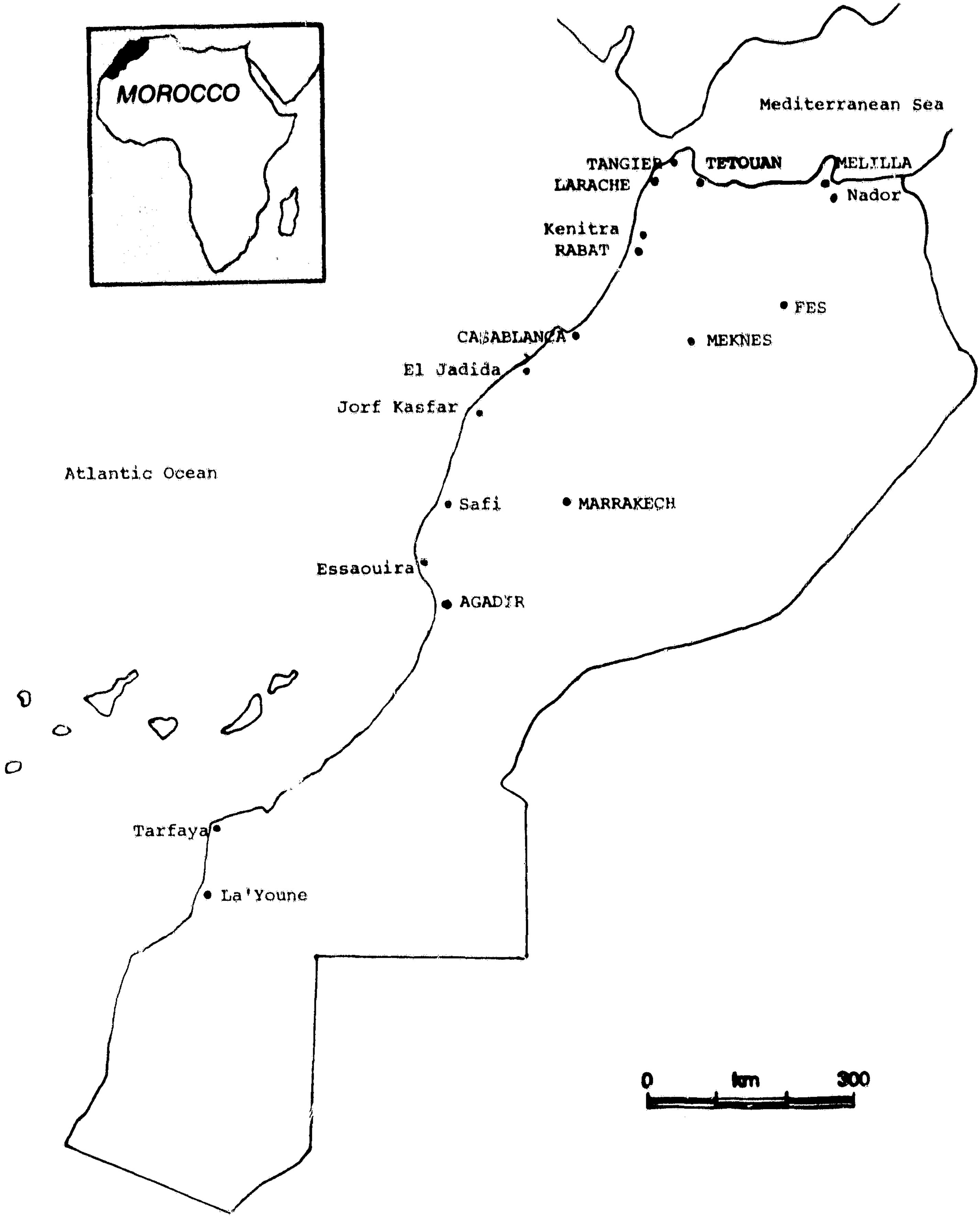
lcd - liters per capita-day

P/V - Photovoltaic

VDC - Volt direct current

WH - watt-hour

Wp - watt-peak


MOROCCO
Mediterranean Sea
TANGIER
TETOUAN
MELILLA
LARACHE
Nador
Kenitra
RABAT
FES
CASABLANCA
MEKNES
El Jadida
Jorf Kasfar
Atlantic Ocean
Safi
MARRAKECH
Essaouira
AGADIR
Tarfaya
La'Youne
0
km
300

MARKET ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS FOR AGRICULTURAL APPLICATIONS IN MOROCCO

Executive Summary

Objectives

The Photovoltaic Stand-Alone Applications Project Office of NASA/Lewis Research Center, Cleveland, Ohio, is conducting an assessment of the market for remote photovoltaic (PV) power systems in worldwide agriculture for the U.S. Department of Energy. The study is to identify PV applications and countries with a high sales potential so that industry may develop appropriate market strategies. The applications considered are those requiring less than 15KW of power and operating in a stand-alone configuration without back-up power. In such applications, cost-competitiveness is based on a comparison with conventional gasoline and diesel power sources. This specific study assessed the market for PV systems in the Moroccan agricultural sector and in rural services.

The objective of the study was to determine for a number of applications the first year of cost-competitiveness, to estimate the market potential thereafter, and to discuss the environment in which PV systems would be marketed and employed. Emphasis is placed on stand-alone applications that are competitive prior to 1986; after this period, with further cost reductions, utility-connected PV systems may become competitive.

The following market elements specific to Morocco are addressed in the report:

- Level of interest, awareness and experience with PV power systems.
- Estimates of potential market size for PV power in agriculture and rural services applications.
- Operating and cost characteristics of gasoline and diesel power systems that will compete with PV.
- Energy, agriculture and development goals, programs and policies which will influence PV sales.
- Appropriate financing mechanisms and capital available for PV system purchases.
- Investment climate for U.S. companies and appropriate methods for conducting business in the country.

Study Approach

The market study for PV in worldwide agriculture was conducted by DHR, Incorporated, with Associates in Rural Development, Inc., as subcontractor. This report on Morocco is the fourth in the case study series on PV applications in agriculture (The Philippines, Nigeria, and Mexico). The scope of these studies includes livestock, forestry, fisheries,

crop production, and rural services.

A study team composed of one "HR and one ARD specialist, accompanied by a NASA representative, visited Morocco from April 19 to May 15, 1981. The major activity of the team members was a series of meetings with a wide variety of Moroccan experts to obtain current data and their evaluations of factors important to introducing PV power systems in agriculture. Site visits were also made to obtain power requirements and energy usage profile data for several agricultural applications. Agencies and individuals contacted include businessmen, officials and scientists at the ministries of Agriculture and Agrarian Reform, Energy and Mines, Public Health, Interior, Post, Telephone and Telegraph, and Transport, and the National Electric Utility, the National Meteorological Service, Central Bank, development banks, Bank of Exterior Commerce, agricultural machinery dealers and associations, energy systems manufacturers and distributors, PV systems manufacturers and distributors, farmers and agribusiness, U.S. and international aid organizations, and the U.S. Embassy and Consulate. Over 70 persons were interviewed, and appropriate sources of published information were consulted.

In addition to performing the data collection activities, the team members gave presentations on PV energy systems and their current applications to a wide variety of audiences. They also distributed sets of brochures consisting of technical and promotional materials obtained from PV companies and from U.S. Government sources.

Various rural and agricultural power uses were investigated for applicability to PV. For the potentially economically feasible applications, the present value of life-cycle cost was compared with that of an alternative power source to determine the first year of cost-competitiveness. The potential market for the next five years was estimated.

Status of PV in Energy Development Plans

Eighty per cent of the commercial energy needs of the Moroccan economy are satisfied by imported petroleum products, and the volume of oil imports has been increasing at approximately 8 to 10 percent per year. In terms of import value, crude oil has risen from 4.5 percent of total imports in 1973 to 23 percent in 1980,[1/] or over $1 billion per year. With overall energy consumption increasing at an annual rate of 10 percent and payments for energy imports growing even more rapidly, Morocco faces an urgent need to develop all indigenous energy potential and reduce its dependence on external suppliers.

The realization that the cost of oil imports may soon exceed Morocco's revenues from the export of phosphates has in fact stimulated interest in developing Morocco's indigenous energy resources. The new, five-year, national energy program, with its $3 billion budget, includes programs to:

- intensify oil and gas exploration;
- develop Morocco's very large oil shale deposits;

1/ Banque Morocaine du Commerce Exterieur statistics, May 1981.

- extract uranium from phosphates and introduce nuclear energy;
- intensify exploration and production of coal, lignite and uranium;
- develop renewable energy, particularly solar energy and biomass; and
- encourage energy conservation.

Morocco is depending heavily on developing its vast oil shale resources. Morocco expects to be producing shale oil by 1983 and to have several commercial-scale oil-from-shale production facilities operating by 1990. Exploration for coal and oil is also being undertaken.

The potential for utilization of solar energy in terms of climate conditions is excellent in Morocco. Radiation is abundant throughout the country, and one peak watt is estimated to provide a daily average output of 4-5 watt-hours.

Presently there is minimal use of solar energy in Morocco. Photovoltaic systems are used to provide power for a remote television repeater station and reportedly for some military communications installations, but there is no active market in Morocco for PV. A number of solar hot water systems are being marketed. The government has recently established a renewable energy research and development center in Marrakech with U.S. AID and Moroccan funding totaling $7.5 million over the next four to five years. Projects include feasibility and preliminary design studies for all PV and other solar technologies (the center itself will be equipped with PV panels), biomass, small hydro and wind systems. American technical involvement has been and will continue to be substantial in the center's projects. Energy policy responsibility is fragmented, and PV companies should become familiar with the various agencies whose activities have potential for PV application.

Despite Morocco's serious search for import-substituting energy sources and an apparent enthusiasm for solar energy, it is clear that solar energy is largely thought of as "energy for the future", a research area, by those in central energy policy roles. The actual use of solar energy in the context of national development plans will not be realized during this plan period. However, "informal" development plans relating specifically to PV are beginning to take shape in a decentralized fashion at a number of agencies. These are agencies such as Ministry of Transport and Ministry of Post, Telephone and Telegraph which are considering PV systems specifically for remote power for TV telecommunications and signalling. Although distant from the formal plan process, these activities represent a positive practical approach to the use of PV systems by the public sector for national policy objectives.

The new national energy policy also intends to accelerate rural electrification, particularly with small and medium scale hydroelectric generation. The World Bank is a major contributor to Moroccan electricity expansion efforts and has lent $200 million from 1974 to 1980 for generation, transmission and rural electrification; however, plans indicate that only 8 percent of the rural population will be served by the grid by 1984, and 10 percent by 1995.1/ Stand-alone diesel and gasoline generator sets, used widely

1/ As reported by the Director of Distribution, Office National d'Electricite. Presently only 7% of the rural population is served by the grid.

throughout rural areas, will continue to be important as sources of electrical power.

Implications of Moroccan Agricultural Development Plans for PV Systems

An emphasis on growth in the agricultural sector is included in the five year plan. Of a total capital budget of approximately $2.5 billion in 1981, agriculture accounts for 15 percent or nearly $400 million, up 93 percent from 1980. Morocco has become a net food importer; therefore an important goal is food self-sufficiency, at least to the point where revenue from food exports pays for food imports. However, it is recognized that the goal cannot be achieved within the plan period.

In order to increase productivity throughout Morocco's large, small-farm agriculture sector, irrigation and dryland agriculture will be emphasized. Furthermore,

- The support price of cereals has been increased by 20 percent;
- Milk price has been increased by 15 percent;
- Rice prices were increased by 23 percent;
- The price of improved seed has been decreased and supply has been increased by 55 percent;
- The taxes on tractors have been lowered by 15 percent;
- The price of fertilizer is remaining the same as last year;
- The amount of credit available for small farmers has been increased.

In addition, the Moroccan fishing subsector will be receiving economic development as well as increased diplomatic attention. In an attempt to boost the industry's competitive position against foreign offshore fishing fleets which are considerably better capitalized, investment will concentrate on modernizing the fishing fleet and extension of the 200 mile economic zone.

Availability of Financing Mechanisms and Funds for PV Investments

Morocco offers an extensive financial system capable of handling and, in fact, facilitating foreign investment. Numerous specialized institutions are able to provide preferential financing as well as experienced advice for investments in specific sectors. Medium and long-term credit is commonly available, although the past several years have seen financing constraints consistent with the government's austerity measures. Loans for small borrowers are difficult to obtain. The financial system attitude would be slightly negative or neutral toward investments in new technology such as PV. Banking community contacts were unfamiliar with PV technology and skeptical about its loan prospects. The National Agricultural Credit Bank is a specialized public financial institution which provides, on average, 70 percent financing for agricultural equipment, supplies and real estate at rates 30 to 40 percent less than commercial rates. Portfolio directors and loan analysts there likewise termed PV "energy of the future" and mentioned that new technologies were not within their purview. However, they felt that if a borrower was able to meet normal

loan criteria, primarily cash flow, there would be no specific barriers to PV financing. This attitude was reflected at other banks as well.

The total amount of credit provided to the private sector by the Moroccan banking system was DH 14.9 billion, in 1978. Two percent was provided by the central bank, 36 percent by specialized institutions and 62 percent by the commercial banks. Correspondingly, 38 percent of this total was medium and long-term credit while 62 percent was short term. The distribution to the private sector for the years 1973 through 1978, showing credit by sector, origin (type of bank) and maturity, is shown in Table 1.

Table 1 DISTRIBUTION OF CREDIT TO THE PRIVATE SECTOR, 1973-78 1/
(MILLIONS OF DIRHAMS, END OF PERIOD)

	1973	1974	1975	1976	1977	1978
BY SECTOR 2/						
Commerce	980	1286	1411	1507	1708	1712
Mining & Industry 3/	1640	2176	2664	2926	3569	3626
Agriculture	608	699	916	1041	1131	1238
Construction	253	421	448	608	840	974
Tourism	187	193	207	200	194	277
Other	647	786	1407	1655	2373	2093
Non-classified	1175	1395	1803	2790	3292	4492
BY ORIGIN						
Deposit Money Bank	3649	4750	5957	6994	8416	9233
Specialized Cred. Instit.	1635	2033	2714	3471	4454	5424
Development Bank	..	515	893	1321	1910	2229
Agriculture Bank	..	604	740	905	996	1232
Constr. & hotels	..	673	815	1025	1314	1691
Other Credit Instit.	..	240	266	220	234	272
Central Bank	206	173	185	262	237	283
BY MATURITY						
Medium & long term	1603	1980	2720	3540	4629	5644
Short term	3887	4976	6136	7187	8478	9296
TOTAL	5490	6956	8856	10727	13107	14940

1/ Includes foreign claims.
2/ Based on the records of Service Central des Risques covering loans extended by all financial institutions except Caisse de Dépôt et de Gestion (CDG). Coverage is not complete as small loans (less than DH 50,000 and DH 100,000 after 1978) are not declared.
.. Not Available
3/ Includes Energy

SOURCE: Morocco: Basic Economic Report, Volume II: Statistical Annex, World Bank Report No. 3289-MOR, Washington, D.C., Dec. 30, 1980, p. 56.

Potential PV Applications in Moroccan Agriculture

During the visits to Morocco, a number of agricultural applications that could use PV power systems were investigated. The criteria used in the selection were:

- Level of production and importance of the product in Morocco.
- Type of operation and its adaptability to use a PV power source.
- Extent of use of the operation in Morocco.
- Extent of the current level of mechanization of the operations (e.g., use of conventional energy systems).
- Size of the power unit required for a typical operation.

The feasibility analysis of individual applications included life-cycle cost comparisons. PV systems costs were based on the PV cost projections of the Jet Propulsion Laboratory's "1980 Photovoltaic Systems Development Program Summary Documents," which were the most complete and up-to-date projections of stand-alone PV costs available (See Table 2).

TABLE 2

PV SYSTEM COST PROJECTIONS PER PEAK WATT (Wp) INSTALLED IN THE U.S.

	Cost of Solar Cells	System Cost w/o Battery Storage Capacity	Battery Storage Cost	System Cost With Battery Storage Capacity
July 1980, stand-alone system	10.60	17.17	3.68	20.85
1982 cost, stand-alone system	2.80	8.05	3.68	11.75
1986 cost, stand-alone system	0.70	3.87	2.68	6.55
1986 cost residential system	0.70	1.60	-	-

Actual conventional (gas or diesel) system data for Morocco in 1981 were the basis for conventional system costs in the life-cycle comparisons. The parameters used in the economic analysis of PV and conventional power systems in Morocco are listed below in Table 3.

TABLE 3

PARAMETERS USED IN ECONOMIC ANALYSIS OF PV AND CONVENTIONAL POWER SYSTEMS

Labor Cost in 1980 $	$200/month
Fuel Cost in 1981 $	Gasoline $3.10/gallon Diesel $1.65/gallon Kerosene $1.25/gallon
Real Fuel Cost Escalation	3%
Inflation	all calculations made in real terms
Discount Rate	15%
Analysis Lifetime	20 years
Life of Conventional System	ranged from 8-10 years

For each of the following applications the use of PV was rejected on grounds of cost, even assuming a waiver of customs duties and sales taxes for public sector purchases and a low 30% margin for PV distributors. These comparisons also take into account PV's projected lower cost in 1986.

Irrigation: At projected 1986 prices, the life cycle cost of the smallest (6.25 HP) diesel motor used to deliver 8.3 l/s from a depth of 15m will be half of the life cycle cost of the PV alternative ($12,000 vs. $23,600). The 15m groundwater depth is minimal for Morocco; at larger depths PV economics are worse. Diesel also has the advantage of financing flexibility (lower front-end cost), operational flexibility, (diesel can be operated continuously if necessary while PV is limited to about five peak hours-equivalent per day), and risk reduction (spare parts and repair facilities for diesel are widely available).

Village water supply: A 20KWp PV system required for supplying water to 2000 villagers from a depth of 50m (for the average Morocco village water supply project) will have a life-cycle cost in 1986 three times that of its 12.5 HP diesel alternative ($131,000 vs. $40,000); front-end costs are $124,000 vs. $2,200. Smaller potable water projects plan to employ used windmill pumps, which are plentiful in Morocco, and with which PV is not now competitive.

Grain Mills: The ordinary mill will require a 10 KWp PV system, which alone will cost $114,600 in 1986, compared with its alternative-- a 12.5 HP diesel motor costing $2200. Due to the need for storage batteries and to the long working hours (which allow efficient use of the diesel equipment), PV is less competitive with diesel in milling than in pumping.

Highway lighting: The break-even distance at which a PV system is cheaper than a grid connection is 10 km in 1982, and 6 km in 1986. Most or all intersections which will be equipped with lights during the period are located within this distance from the grid.

The possibility for using PV for livestock watering, veterinary extension posts, cold storage for fisheries, and educational television was investigated but rejected, primarily because the entire market for any power source in these applications in non-grid connected locations over the next five years will be insignificant. A modest potential for PV use was identified in some non-agricultural rural services, such as refrigerators for rural clinics and rural radio-telephones. The field findings and the economic analysis offer little support to the thesis that because of the absence of grid electricity in larger areas of Morocco, these areas offer considerable markets for PV power before 1986.

The 1986 time horizon is significant because by that date, PV is projected to be cost-competitive with grid electricity as a fuel saver for residential and industrial applications. When this situation is attained, vast markets will open for PV in the areas which already have electricity, and the assessment of applications in non-grid-connected locations is likely to lose its motivation.

Other Feasible Rural Applications

During the course of the team's visit it became apparent that non-agricultural applications may present a noteworthy Moroccan PV market.

These applications include:

Rural TV Receivers: The Television Directorate believes that if PV-powered television sets were widely available at a reasonable price, a large rural market could be successfully tapped, assuming:

(a) design of a PV module specifically to fit the TV sets and batteries commonly in use in rural Morocco, containing all the necessary elements (including connecting cables, mounting rods, etc.) and of the minimum size required for powering the TV set (not a system designed to power TV, lighting and various home appliances together);

(b) proper advertisement of the systems; and

(c) competition among various dealers to keep dealer margins to a minimum.

TV Repeater Stations: A PV-powered TV repeater station has been functioning in Morocco for two or three years with better reliability and maintainability than tne diesel alternative. The equipment is from the U.S.

Microwave Relay Stations: The Ministry of Post, Telephone and Telegraph is now considering using PV to power future microwave relay stations.

Railroad Signals:	Opportunities exist to use PV to power warning lights.
Marine Signals:	Light buoys and lighthouses to be installed by the Directorate of Secondary Ports hold some promise for PV application.
Airport Signals:	The Air Directorate is interested in powering radio beacons by PV. Telephone systems at small airports might also be PV-powered.
Traffic Counters:	The National Center for Highway Research is interested in replacing batteries to power traffic counters with PV.
Rural Radio Telephones:	The Ministry of Post, Telephone and Telegraph has installed a PV-powered radio telephone in a remote location with satisfactory results.
Refrigerators for Rural Clinics:	PV-powered medical refrigerators would be advantageous in locations where the transport and cost of butane containers pose real problems. The USAID/Rabat is currently considering buying five PV refrigerators.

Market Assessment

Order-of-magnitude market size approximations, based on life-cycle cost comparisons and other factors, are as displayed in Table 4.

Table 4 - Morocco PV Market Potential (1981-1986)

(1)	Rural TV receivers	8750 units @ 20 Wp	175 kWp
(2)	TV repeater stations	40 units @ 1 kWp	40 kWp
(3)	Microwave stations	10 units @ 3.6 kWp	36 kWp
(4)	Railroad stations	100 units @ 300 Wp	30 kWp
(5)	Marine Signals:		
	light buoys	100 units @ 240 Wp	24 kWp
	lighthouses	20 units @ 600 Wp	12 kWp
(6)	Traffic counters	100 units @ 60 Wp	6 kWp
(7)	Airport signals	10 units @ 300 Wp	3 kWp
(8)	Rural radio telephones	40 units @ 100 Wp	4 kWp
(9)	Refrigerators for rural clinics	50 units @ 200 Wp	10 kWp
	Total Maximum Demand for PV		340 kWp

At an average customer cost for complete installed systems from \$18/WP to \$30/Wp, the total potential market value of 340 KWp is estimated in the range of \$6.1 million to \$10.2 million over the period.

In all cases except PV-TV the clients are public agencies. The above estimates of this institutional market are an approximation based on the

declared objectives and expected budgets of agencies and services interested in purchasing PV systems as indicated by the directors of these organizations. A more definitive market estimate may be possible in a few months upon the publication of the 1981-1985 five-year plan. Realization of the potential institutional market will further depend on:

- the degree of success of the government agencies concerned in obtaining and executing the planned budgets; and
- the cost-competitiveness of PV systems in each individual case, which in turn will depend to a considerable extent on the markup of the distributors of PV systems and on the customs duties levied on PV.

The growth rate of the potential PV market over the period 1981-1986 is too uncertain to permit a further division of the five-year market potential into annual sales potential or targets. For example, in some applications judged to have significant potential for PV, such as TV receivers and marine signals, the market will require early stimulation, advertising, and testing with sales accelerating in several years. It can only be estimated that certain applications in which pilot experience already exists in Morocco (notably radio-telephone, microwave and TV repeater stations) may soon be ready for more substantial orders, while in other uses (e.g., railroad, airline and marine signals) a pilot demonstration must be the first step.

In the study, rural TV receivers are shown to have a potential market over the next five years larger than all other applications combined. This potential is enhanced by the existence of dealer credit systems which can be used for financing the purchase of PV power, by the inconvenience of the alternative power source (battery recharging), by the cost-competitiveness of PV in this use, and by the prestige it is likely to confer on the user. An important consideration for the development of PV markets in Morocco and elsewhere is that widespread use of "PV-TV" could also be the ideal means to familiarize the rural sector with PV power and to create the distribution and maintenance network which will facilitate the spread of other PV uses as they become cost-competitive. However, at present this is only a potential. Exploitation of the PV-TV market will depend on:

- manufacturing dependable PV packages which readily fit the types of TV sets and batteries in common use in Morocco (or elsewhere);
- proper advertising; and
- encouragement of competition among dealers to maintain a reasonable consumer price.

Business Environment for Marketing PV Systems

Various characteristics of the Moroccan business climate are noted in Table 5. American PV manufacturers face both advantages and disadvantages in trying to develop the Moroccan market. The principal advantages are that in the public sector there is a genuine enthusiasm for PV and other solar technology, as well as relative awareness and knowledge of PV applications

Table 5 - Characteristics of the Moroccan Business Climate

Area	Present Status
Foreign Competition	• American firms generally well-regarded • Strong competition from the well-established French • No Moroccan PV production; little other solar production • Generator manufacturing under German, British, French and American licenses takes place in Morocco • Increasingly attractive investment climate • Credit institutions neutral or slightly negative to investment in new technologies • Stated policy of attracting American firms • No specific incentives for solar or PV companies; some are under consideration • 50% Moroccan directorship required for most companies • Long-term capital is scarce
Business Environment	• Well-established conventional generator market • Private investment encouraged in priority sectors by tax and other incentives • PV marketing now done through pump or electrical supply distributers • Low wages for workers
Awareness of PV	• Public officials in relevant sectors well aware and often enthusiastic • Farmers generally unaware and often skeptical • Banking sector generally unaware and sometimes skeptical
Regulations and Tariffs	• Customs duties exemptions • 100% foreign ownership eligibility of solar businesses under consideration • Business registration requirements are complex • Import licenses required for only about 25% of imports • Import regulations now being clarified

and advantages in some important sectors such as telecommunications and agriculture. In addition, a number of American PV companies are becoming active and establishing name recognition. Also Moroccan general business investment incentives are increasingly attractive and there is a stated policy of attracting American firms.

Disadvantages are important as well, and the most important have to do with PV cost-competitiveness and the well-established market for conventional electrical generator equipment. No specific incentives exist for PV or solar companies, although some are under consideration. Long-term capital is scarce in Morocco, as are an overall awareness of PV systems and private entrepreneurial interest. And American firms, although generally well-regarded, face keen competition from the French who are well-established in Morocco private and public sector trading. Tariff import regulations present some confusion, although these are being progressively clarified.

Conclusions

The analyses of potential PV applications in Morocco indicate that there is very little PV market potential in the agricultural sector in the near term, and other rural sector service applications present only slightly better potential. The use of PV was rejected on grounds of cost for the agricultural and rural service applications of irrigation, village water supply, grain mills, and highway lighting. The possibility for using PV for livestock watering, veterinary extension posts, cold storage for fisheries, and educational television was investigated but rejected, primarily because the entire market for any power source in these applications in non-grid connected locations over the next five years will be insignificant. A modest potential for PV use was identified in some non-agricultural rural services, such as refrigerators for rural clinics and rural radio-telephones.

However, significant market potential was found for telecommunication and signalling applications. The maximum size of the potential market for PV in Morocco over the next five years is estimated to be about 340KWp:

Morocco PV Market Potential (1981-1986)

Rural TV receivers	175 kWp
TV repeater stations	40 kWp
Microwave stations	36 kWp
Railroad stations	30 kWp
Marine Signals:	
light buoys	24 kWp
lighthouses	12 kWp
Traffic counters	6 kWp
Airport signals	3 kWp
Rural radio telephones	4 kWp
Refrigerators for rural clinics	10 kWp
Total Maximum Demand for PV	340 kWp

In sum, the growth path for PV power in Morocco will likely be similar to its historic growth path in the U.S. Until PV is able to supplement grid power as a daytime electricity saver, i.e., after 1986, the market for PV power in Morocco will be in telecommunications, signalling, battery charging applications, and small motors.

MARKET ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS FOR AGRICULTURAL APPLICATIONS IN MOROCCO

1.0 INTRODUCTION

1.1 Background

The United States National Photovoltaic (PV) Program has been established by the U.S. Department of Energy (U.S. DOE) to advance PV power systems to the economic marketing stage where they can contribute significantly to the U.S. energy requirements by the end of this decade. Ongoing research, development and demonstrations are directed at achieving major system cost reductions and field experience with PV power systems. The program is managed by the U.S. DOE and consists of several project centers, one of which is the Photovoltaic Stand-Alone Applications Project Office at NASA Lewis Research Center, Cleveland, Ohio. This project office is conducting international market assessments to ascertain whether stand-alone PV power systems can provide useful and economically productive power for various applications in developing countries during the next several years. This report on Morocco is the fourth in the case study series on PV applications in agriculture (The Philippines, Nigeria, and Mexico).

1.2 Objectives

The types of potential photovoltaic applications considered in the contract are those requiring less than 15KW of power and operating in stand-alone configuration without back-up power. These applications include: irrigation, rural water supply, post-harvest operations, food and fiber processing and storage, and livestock operations. A team composed of representatives of DHR, Incorporated, Associates in Rural Development, Inc., and the NASA/Lewis Stand-Alone Applications Project Office, visited Morocco from April 19 to May 15, 1981. The primary purpose of this report is to provide an assessment of the market for stand-alone photovoltaic systems in Moroccan agriculture.

During the course of the team's visit it also became apparent that non-agricultural applications may represent a significant Moroccan PV market potential. Some of these are remote microwave and TV repeater stations, rural TV receivers, refrigeration for rural clinics, and a number of transportation signalling applications. This report performs the market analysis for these

applications, using the same methodology as for the applications in the agriculture sector.

This study proposes to identify applications with high PV sales potential so that photovoltaic suppliers and distributors can develop appropriate marketing strategies. The market analysis provides the following essential market information for Morocco:

- Level of interest, awareness and experience with PV power systems.
- Estimates of potential market size for PV power applications in the agriculture sector.
- Operating and cost characteristics of gasoline and diesel power systems that will compete with PV.
- Energy, agriculture and development goals, programs and policies which will influence PV sales.
- Appropriate financing mechanisms and capital available for PV system purchases.
- Investment climate for U.S. companies and appropriate methods for conducting business in the country.

In addition to the data collection activities, the team members gave a presentation on PV energy systems and their current applications to a wide variety of audiences. They also distributed sets of brochures consisting of technical and promotional material obtained from PV companies and from U.S. Government sources.

1.3 Study Approach

The approach consists of a focused data collection effort in the country followed by a detailed analysis and a market assessment based on this data. This process is described in greater detail below.

1.3.1 Moroccan Information and Data Base

The major activity of the team members was a series of meetings with a wide variety of Moroccan experts to obtain current data and their evaluations of factors important to introducing PV power systems in agriculture. Site visits were also made to obtain power requirements and energy usage profile data for several agricultural applications. Agencies and individuals contacted include businessmen, officials and scientists at the following:

- Ministry of Agriculture and Agrarian Reform
- Ministry of Energy and Mines

- Ministries of Public Health -- Federal and Provincial
- Office National de Electricite (National Electric Utility)
- National Meteorological Service
- Ministry of Interior
- Ministry of Post, Telephone and Telegraph
- Ministry of Transport
- Central Bank, Development Banks and Bank of Exterior Commerce
- Agricultural Machinery Dealers and Associations
- Energy Systems Manufacturers and Distributors
- Photovoltaic Systems Manufacturers and Distributors
- Farmers and Agribusiness
- U.S. and International Aid Organizations
- U.S. Embassy and Consulate

Appendix A gives the names and addresses of about 70 individuals who were interviewed during the Moroccan visit.

The type of information collected included the following:

- Aggregate statistics including: level of agricultural production; type of production; distribution of production by size of operation; solar insolation; production trends.
- End-Use system configuration description and characterization of: current agriculture practices in terms of: operations; machinery used/duration of use; availability of resources (labor, parts, energy, etc.); PV impacts; economics; financing; diesel/gasoline/ electricity use; and costs of competing systems.
- Balance-of-system availability and barriers to the implementation of PV systems that are related to: costs and availability of balance-of-system parts or equipment; skills of workforce.
- Government energy policies and attitudes, both existing and planned: rural electrification; prices/supply; renewable energy; consumption; type of energy used; PV systems.
- Government agricultural policies, both existing and planned, with regard to: crop production; introduction of new techniques and equipment; role of renewable energy systems in agriculture; incentives (financial and other); land reform/land use; employment generation; import of agricultural systems; storage; research work; marketing.

- Financing mechanisms and availability of credit for PV use in agriculture.

In addition, qualitative information was also sought in order to allow a realistic and complete market assessment. These areas include:

- Government attitudes and policies including: the level of awareness or interest in PV--especially units of less than 15 KW for agriculture purposes, and policies conducive to or hindering PV marketing and use.

- Marketing channels and identification of potential barriers/incentives in the marketing of PV systems, including the present structure of markets; buying patterns; service/installation; profits; and availability of equipment.

- Business environment, incentives and barriers that U.S. companies face when planning to conduct PV business or organize joint ventures.

1.3.2 Data Analysis and Market Assessment

The data and information discussed above have been evaluated to develop an integrated market assessment for PV systems in Morocco. The assessment pays particular attention to:

- Moroccan national development plans in agriculture, energy and overall economic development, in which the government plays a central role.

- Feasibility of PV for use in Moroccan agriculture and other applications.

- Cost-competitiveness of PV compared to its least-cost practical alternative.

- Awareness and attitudes toward investing in PV systems, including non-agricultural applications.

- Funding availability and mechanisms.

- Suitability of existing market structures for distributing installing and maintaining PV systems.

For economic comparisons of PV power systems to alternatives, the study performs financial analysis for the near to mid term, i.e., the next five years. The data requirements include power, usage profiles, current and estimated future

use in Moroccan agriculture and other applications; competing systems; cost, financial and economic parameters; solar insolation data; and projected PV system costs. The objective of the analysis was to determine for each application the first year of cost-competitiveness and the market potential thereafter. For the economic comparison, the analysis was based on the PV cost projections made at JPL[1/], which are the most complete and up-to-date projections of PV costs available. JPL has projected PV system costs as follows:

PROJECTED COSTS OF PV POWER SYSTEMS
INSTALLED IN THE U.S., IN 1980 DOLLARS PER PEAK WATT (Wp)

	Cost of Solar Cells	System Cost w/o Battery Storage Capacity	Battery Storage Cost	System Cost With Battery Storage Capacity
July 1980, stand-alone system	10.60	17.17	3.68	20.85
1982 cost, stand-alone system	2.80	8.05	3.68	11.73
1986 cost, stand-alone system	0.70	3.87	2.68	6.55
1986 cost, residential system	0.70	1.60	-	-

The outputs of the financial analysis are combined with the team's overall assessment to give an estimate of the market size in Morocco. It should be noted that market size estimation procedures used in this analysis assume that if PV is to obtain a significant market share, it must be cost-competitive with the least-cost, practical alternative. There are, however, cases where other advantages of PV systems far outweigh cost concerns. One example of such an application is remote operation of a signaling or monitoring device. As appropriate, such applications are noted.

1.4 Report Organization

Chapter 2 of this report presents an overview of Morocco in terms of important economic and demographic characteristics, its energy situation,

1/ "1980 Photovoltaic Systems Development Program Summary Documents." Jet Propulsion Laboratory, Pasedena. (See Appendix B for more detail)

relevant government organizations, climate, agricultural regions, and major domestic export crops. Chapter 3 describes development plans and policies as they influence PV systems use in agriculture and other applications. Chapter 4 describes the financial institutions and funding programs that can play a major role in financing PV sales. Chapter 5 describes the relevant business environment in Morocco, and the specific advantages and disadvantages for developing PV markets. Chapter 6 describes in detail potential PV applications in the agricultural and rural sector in Morocco. Chapter 7 describes in detail other PV applications in Morocco such as telecommunications and signalling. Chapter 8 assesses the overall market size and describes the major conclusions of the analysis.

2.0 COUNTRY OVERVIEW

2.1 Demography and Economy

Morocco has a population estimated at over 20 million in 1980; with a high annual growth rate of 3.1 percent, making it one of the most populous nations in the Arab world. Fifty-nine percent of the population is classified as rural and forty-one percent as urban, with a much faster urban growth rate (4.4% vs. 1.8%) due to rural-to-urban immigration. Per capita gross national product (GNP) is estimated at U.S. $842 (1980),[1/] reflecting very little change from 1979.[2/] The government is a constitutional monarchy with great political power concentrated in the King, who is both head of state and the spiritual leader of Morocco's 99 percent Moslem population.

Morocco is on the northwest corner of Africa with extensive coastlines on both the Mediterranean and the Atlantic. It is the closest African nation to Europe separated by the strait of Gibralter, and shares borders with Algeria to the east and Mauritania and the Western Sahara to the southeast and south. Morocco's topography is sharply divided into open, agriculturally fertile lands on the Atlantic and Mediterranean plains, the high and rugged Atlas and Rif mountains in the center and north of the country, and arid plateaus and the Sahara covering the northeast and eastern parts of the country. The major cities (Casablanca, Rabat, Marrakech, Fez, Agarira, Tangier) and the vast majority of the population are concentrated in the coastal and plains areas.

The Moroccan economy as a whole is characterized by small but increasingly modern and productive industrial, commercial and service sectors in urban areas contrasted by a large generally traditional agricultural/rural sector.

1/ At 1980 exchange rate of $1 = 3.8 dirhams (DH); current exchange rate is approx. $1 = 4.8 DH.

2/ "Foreign Economic Trends and Their Implications for the U.S.:Morocco", U.S. Dept. of Commerce, International Trade Administration, Washington, D.C., February, 1981.

Morocco has been experiencing growing food and balance-of-trade shortfalls in recent years, and economic problems are exacerbated by oil import price increases (Morocco is 80% dependent on imports) and the continuing Western Sahara conflict in the south. Its short-term problems are largely financial, and Morocco depends to a certain degree on donor assistant and concessional loan terms for development. However, Morocco's longer term potential remains positive due to its wealth of resources, particularly phosphate, of which Morocco is the international market's largest supplier, and oil shale. (Key economic indicators are shown in Appendix C).

Morocco has a total land area of 69 million hectares, about the size of Oregon and Washington together, of which 7.7 million ha are suitable for cultivation, and 20 million ha are in semi-arid or mountain regions suitable only for grazing and forests. Permanent irrigation covered 720,000 ha in 1977. About 5.3 million ha of the 7.7 million of agricultural land are cultivated each year; the remainder is under tree crops (0.4 million ha) or left fallow (2.0 million ha).

2.2 Agricultural Sector Overview

The agriculture sector, including fisheries and forestry, is very important to the Moroccan economy, normally accounting for 20 to 25 percent of GNP and 60 percent of the total workforce. In recent years, however, the government has devoted considerably less attention to improvement of the agricultural sector than to mining and industrial development. Consequently, agricultural production has remained fairly constant, which has resulted in large food imports recently to satisfy the needs of Morocco's rapidly growing population. Agriculture's share of GNP is estimated at 18.7 percent in 1980.[1/] In addition, Morocco has suffered a protracted drought for the first half of 1981, virtually destroying the winter cereals crop and certain to have serious impacts on external trade and the overall economy this year.

The agricultural trade deficit for the first 11 months of 1980 was DH 848 million, or $223 million, representing 13 percent of the country's total trade deficit for the period.[2/] Because of population growth and

---

1/ "Monthly Information Review," Banque Morocaine du Commerce Exterieure, No. 34, April 1981, p. 2.

2/ "Morocco: Agricultural Situation," Attache Report #MO-1006, U.S. Embassy, Rabat, Morocco, February, 1981, p. 9.

inconsistent weather in the past several years, Morocco has slipped from being a net food exporter to becoming a net food importer, with both quantity and value of food imports increasing steadily. The primary imports are wheat, sugar beets and cane, corn, oilseeds and vegetable oils. The primary exports are citrus fruits, vegetables, fish, potatoes and pulses.

Of Morocco's 5.3 million ha under cultivation, about 4.3 million ha are planted under winter cereals, 500,000 ha under pulses, 140,000 ha under vegetables, 60,000 under sugar beet, and the remainder under oilseeds, cotton and forage crops. Most cultivated land is found in the northern half of Morocco and along the Atlantic Coast where the climate is mediterranean. Aridity increases toward the south becoming desert, east and south of the Atlas mountains. Most industrial crops, forage crops, vegetables and citrus fruits are grown under irrigation, which also provides almost all export crops. About 50% of Morocco's cultivable land receives about 14 inches or less of rainfall, and is generally put under a barley/fallow rotation. Most of Morocco's rainfed areas are characterized by traditional agricultural practices. Despite government efforts, limited use is made of fertilizers, pesticides, herbicides, high yielding seed and farm machinery. As a result, crop yields and livestock productivity are generally low.

Livestock raising is primarily extensive, based on grazing of pasture land. Intensive livestock production, based on cultivated forage crops, barley, or industrial crop residues, is rapidly becoming important in irrigated and high rainfall areas. About one-third of agricultural GNP is generated by the livestock subsector. Estimates of Moroccan livestock in 1980 are fragmentary but are as follows: 14.2 million sheep, 5.1 million goats, 3 million cattle, 300,000 horses and 10,000 swine.[1/] Crop production in Morocco is shown in Table 2-1.

1/ "Morocco: Agricultural Situation," op. cit., p. 31.

Table 2-1

Morocco Agriculture Production

1979 and 1980 (thousands of MT)

Item	1979	1980
Durum Wheat	1260	1331
Bread Wheat	540	480
Barley	1886	2210
Corn	311	333
Pulses (Peas, lentils, broad beans)	262	231
Fish	260	NA
Oilseeds (Sunflower, peanut, cottonseed)	46	54
Olives	250	175
Citrus	877	1037
Sugar beets & cane	2453	2561
Tomatoes	412	400
Potatoes	386	390
(Total vegetable)	1200	NA

SOURCES: "Morocco: Agriculture Situation," Attache Report MO-1006, U.S. Embassy, Rabat, Morocco, February 1981 and "Memorandum on Morocco's Agricultural Sector," World Bank Report No. 2667a-MOR, Washington, D.C., May, 1980

Over half the farms in Morocco are under 7 ha, and one-quarter of cultivated land is in farm holdings having an average size of 1.6 ha. Since 1966 the government has distributed 350,000 ha of farmland formerly occupied by Europeans. However, land is still inequitably distributed and the vast majority of families use traditional farming methods on small farms. Very little credit is available to small farmers in practice. Forty percent of farm lands are in holdings of 10 to 50 ha, and almost 17 percent are in holdings of over 50 ha. Mechanized, industrial farming is conducted on some of these larger holdings, concentrating on cash crops for export such as citrus, vegetables and oilseed products.

Farm input subsidies are available to all categories of farmers, and they are designed to induce farmers to use modern inputs (fertilizer, machinery,

irrigation, seeds, etc.) to increase crop and livestock production. However, large farms obtain most of these subsidies and small farm practices and production continue to stagnate. Morocco also has a policy of subsidizing some retail food prices (flour, sugar, oils, milk) to keep consumer food costs down, and of providing fixed prices for some crops to producers. These subsidies have had questionable impacts on production levels.

The prospects for continued growth in agricultural production are presently threatened by the drought, and emergency measures to combat it are being initiated by the government. Otherwise, the government is intending to place increased emphasis on the sector in the new five year plan (see Chapter 3), with greater attention to small farm productivity, irrigation, dairy and sugar self-sufficiency, modern inputs, and export expansion. Both the World Bank and U.S. AID have significant agriculture development aid programs active in Morocco. (For more detail on Morocco's agriculture sector, see Appendix D).

2.3 Energy Sector Overview

The commercial energy needs of the Moroccan economy are satisfied principally by petroleum products, hydroelectricity (9 percent) and coal (10 percent). Virtually all petroleum is imported, although significant refining is conducted in Morocco. The volume of oil imports has been increasing at approximately 8 to 10 percent per year. In terms of import value, crude oil has risen from 4.5 percent in 1973 to 23 percent in 1980[1/] of total imports, or over $1 billion per year. With overall energy consumption increasing at an annual rate of 10 percent and payments for energy imports growing even more rapidly, Morocco faces an urgent need to develop all indigenous energy potential and reduce its dependence on external suppliers.

The realization that the cost of oil imports may soon exceed Morocco's revenues from the export of phosphates has stimulated interest in developing Morocco's energy potential. Morocco is depending heavily on developing its vast oil shale resources, of which it has the world's fourth largest estimated reserves (after the U.S., Brazil and the U.S.S.R.). In cooperation with several American firms, Morocco expects to be producing shale oil by 1983 and to have several commercial-scale oil-from-shale production facilities

---

1/ Banque Morocaine du Commerce Exterieur statistics, May 1981.

operating by 1990. Morocco may well be the world leader at present in applying retorting technology.

Morocco also has some coal resources, whose production is heavily subsidized, and there are indications that these resources are significantly greater than present known reserves. **Production was 720,000 MT in 1978, up** from 565,000 MT in 1973 (see Table 2-2) and should continue to follow similar growth with the need for electricity and the need to displace oil use.

Table 2-2

Energy Production

	Unit	1970	1971	1972	1973	1974	1975	1976	1977	1978
Coal..................	1000 t.	433.0	474.5	546.8	565.0	574.0	652.0	702.0	707.0	720.0
Crude oil..............	1000 t.	44.2	22.6	28.4	42.1	25.1	20.3	8.1	22.0	24.3
Natural gas..........	million m3	43.1	47.0	62.9	83.5	77.2	70.8	79.1	86.2	84.5
Electric energy.....	million kwhr	2,025.6	2,193.4	2,470.3	2,790.0	3,068.3	3,269.5	3,348.2	3,670.1	4,100.0
- Hydroelectricity	" kwhr	1,345.8	1,562.9	1,631.6	1,233.0	1,382.0	1,029.8	977.4	1,273.5	1,393.0
- Thermal.........	" kwhr	679.8	630.5	838.7	1,557.0	1,686.3	2,239.7	2,370.8	2,396.6	2,707.0

SOURCES: Ministere de l'Energie et des Mines, Office National d'Electricite

Known supplies of oil and gas will be exhausted within a generation at current utilization rates (approximately 24,000 MT/year for oil and 84 million m^3/year for gas (See Table 2-2). There are strong indications, however, that Morocco has as yet undiscovered oil deposits, and has begun limited coastal exploration for oil. However, the costs for exploration and eventual development is high, and Morocco will remain dependent on imported petroleum for some time to come. Morocco imports crude oil and refines it domestically into numerous finished products through a well-developed refining industry. Fuel prices are regulated at following prices, based on a May 1981 exchange of $1 = 4.8 Dh.

Gasoline: $3.10
Diesel: $1.65
Kerosene: $1.25

Diesel and kerosene are subsidized because of their importance to transport and agriculture; but higher prices for each fuel have been reported in rural areas. Official discussion of reducing or eliminating fuel subsidies is

minimal at present.

Electricity is supplied throughout Morocco by the grid owned and operated by Office National d'Electricite (ONE). Electricity production was 5 billion kWhr in 1980, up 15 percent from 1979. Thirty-six percent was hydro and sixty-four percent thermal (40 percent oil, 24 percent coal). Electricity demand and production has been rising at a consistent rate in Morocco over the past 15 years, with a rapid acceleration particularly since 1973 in both installed capacity and demand to meet the relatively recent needs of development of the industrial, commercial and urban sectors. Figures 2-1 and 2-2 show these trends for Morocco's electricity sector.

Electricity supplied by the grid is reliable and fairly reasonable (8 to 11¢ per kWhr, depending on region and class of customer at existing May 1981 exchange rate of $1 = 4.8 Dh), provided at 50 cycle AC. However, the grid serves predominantly urban areas and rural electrification is proceeding slowly. Fifty-nine percent of the population is classified as rural, and only 7 percent of this is served by the grid. The World Bank is a major contributor to Moroccan electricity expansion efforts and has lent $200 million from 1974 to 1980 for generation, transmission and rural electrification; however, plans indicate that only 8 percent of the rural population will be served by the grid by 1984, and 10 percent by 1995.[1/] Stand-alone diesel and gasoline generator sets, used widely throughout rural areas, will continue to be important as a source of electrical power.

2.3.1 Solar Energy

Presently there is minimal use of solar energy in Morocco. Photovoltaic systems are used to provide power for a remote television repeater station and reportedly for some military communications installations, but there is little PV marketing activity. Two U.S. firms have recently established representatives in Casablanca, Morocco. A number of solar hot water systems are being marketed. Many wind machines are in operation throughout Morocco for water pumping, largely of the Aeromotor design, but far more are inoperable and in severe states of disrepair.

1/ As reported by the Director of Distribution, ONE, April, 1981.

Figure 2-1: Electrical Demand, 1963-1979

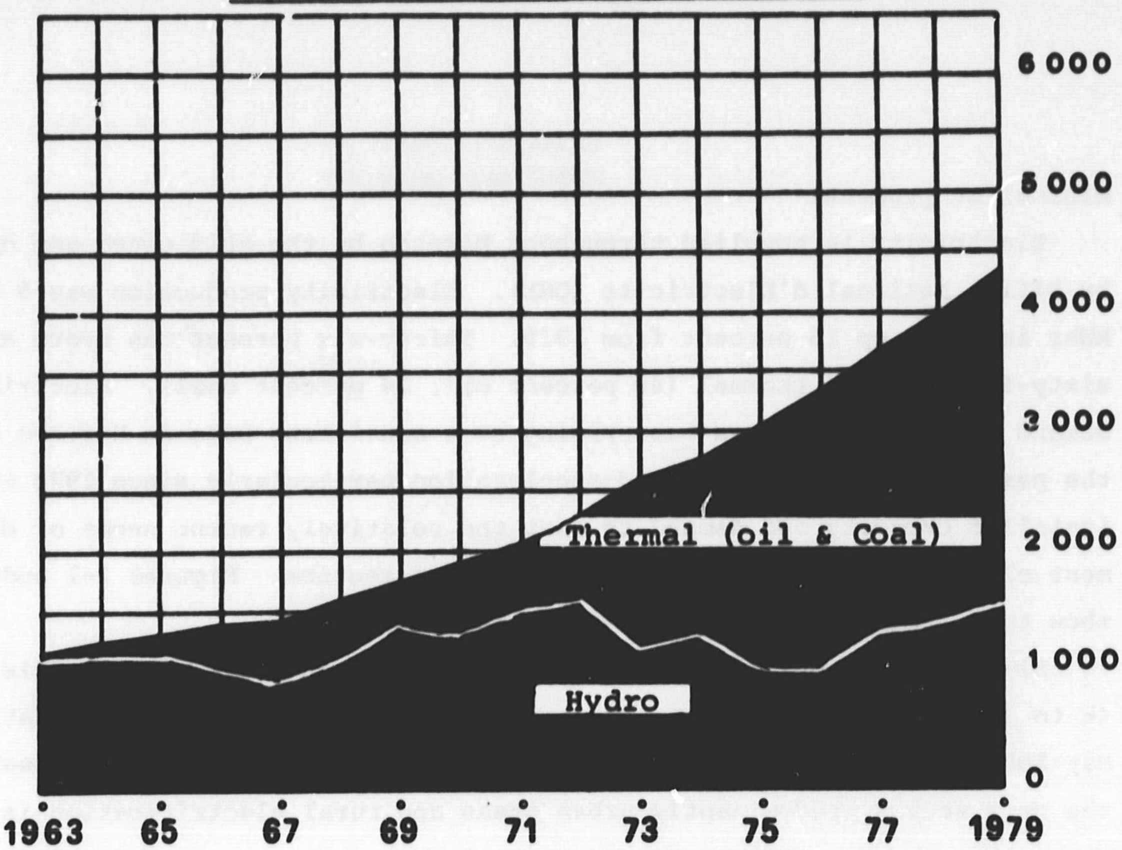
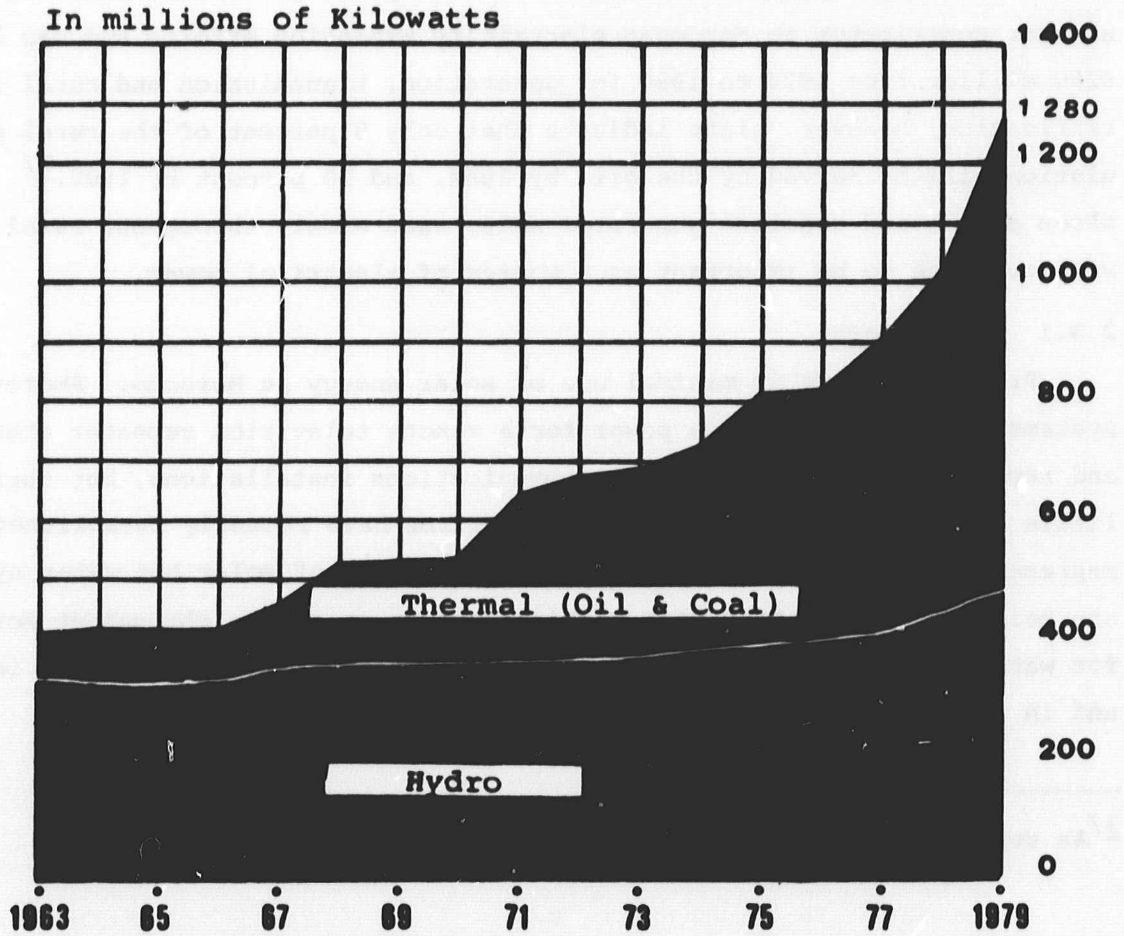


Figure 2-2: Installed Capacity of the ONE, 1963-1979



SOURCE: Rapport D'Activity: 1979, Office National de l'Electricite, 65 Rue Aspirant Lafuerte, Casablanca, Morocco, 1980.

The interest in developing Morocco's indigenous energy resources has stimulated enthusiasm for utilizing Morocco's renewable energy potential. The government has an official policy to actively promote solar development and has recently established a renewable energy research and development center in Marrakesh with U.S. AID and Moroccan funding totaling some $7 million over the next four to five years. Projects include feasibility and preliminary design studies for PV and other solar technologies (the center itself will be equipped with PV panels), biomass, small hydro and wind systems. American technical involvement has been and will continue to be substantial in the center's projects.

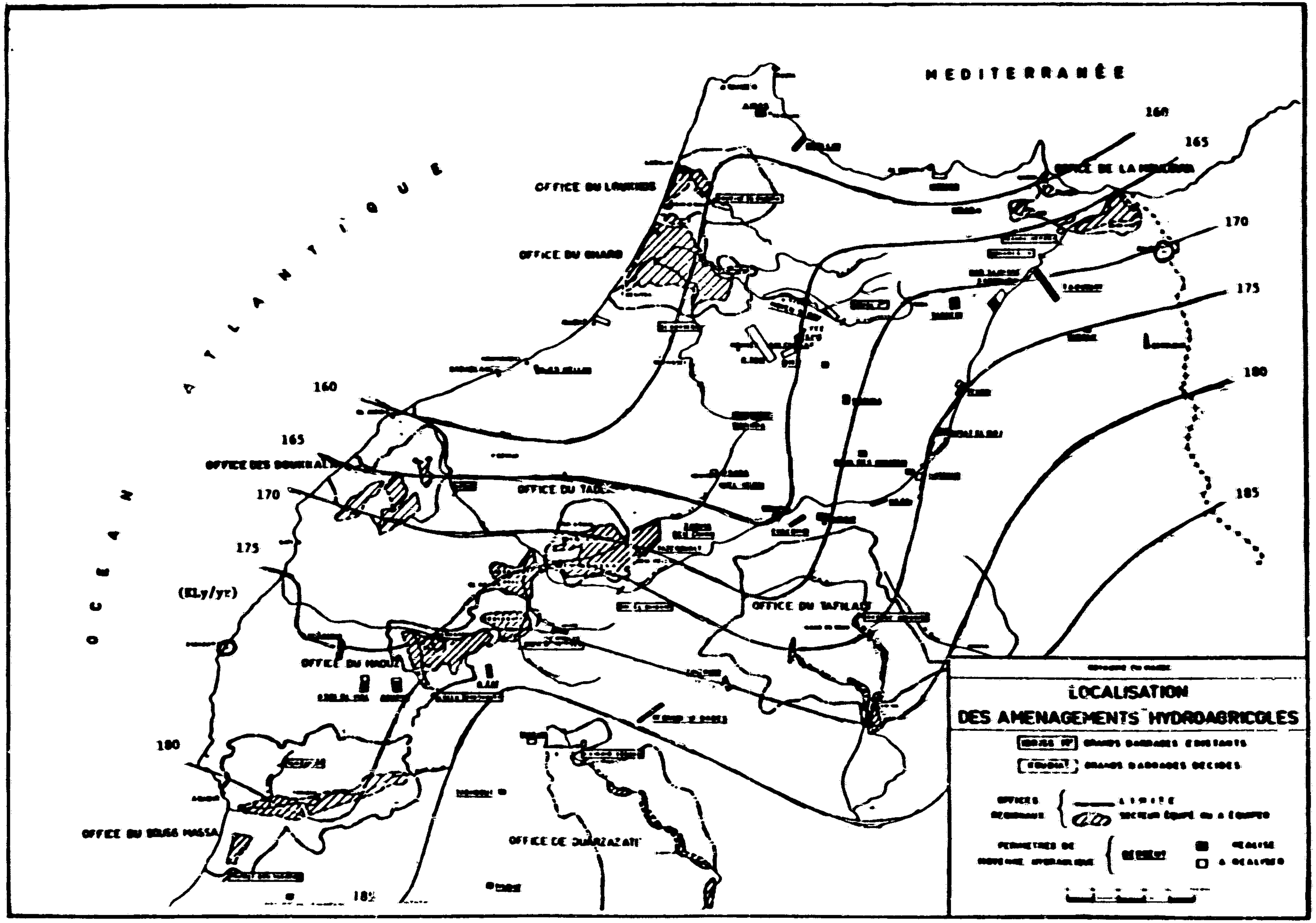
In terms of climatic conditions, the potential for utilization of solar energy in Morocco is excellent as insolation is abundant throughout the country. Insolation data are available for Casablanca for the past ten years, and quantitative data for 23 other locations throughout the country is provided in terms of monthly sunshine hours over the past twenty years (Appendix E). Isohels for Morocco in KLy/yr are shown in Figure 2-4. For purposes of the PV system size calculations performed in chapter 6 and 7, one peak watt is estimated to provide a daily average output of 4 watt-hours.[1/]

2.4 Key Public Sector Organizations in Energy

The Ministry of Energy and Mines (Ministre d'Energie et des Mines) has chief responsibility in Morocco for the formulation of national energy policy, although ultimate decision making on policy matters rests with the King. The Ministry is responsible for research and for the direct supervision of production units. The ONE (Office Nationale d'Electricite) is the semi-autonomous national electric utility company, and it reports directly to the Ministry of Energy and Mines. The newly established Renewable Energy Development Center (Centre du Developpement des Energies Renouvelables) in Marrakech is also under the auspices of Energy and Mines, which consults with AID on the Center's research program and coordinates

1/ The range using the Casablanca measurements is 3.1 to 6.8 watt-hours per day. Some PV systems may be sized at 4.8, 5.0 or even higher average outputs, depending on location and load characteristics. However, 4 whr/day is also the average output figure used by PV firms marketing in Morocco.

FIGURE 2-4: SOLAR RADIATION INTENSITY LINES (ISOHELS) FOR MOROCCO



Units: Kilolangleys/year

the Center's activities with national policy and with other federal agencies involved in renewable energy projects.

Despite these roles of the Ministry of Energy and Mines, energy sector responsibility is fragmented. The Prime Minister makes decisions on the price structure of various fuels and on energy investment planning. The Ministry of the Interior supervises large parts of the urban electricity and gas distribution systems as well as budgets for water supply in rural communities. Specific divisions of other agencies, such as Ministry of Agriculture (e.g., different divisions for irrigation systems and potable water) and the Ministry of Post, Telephone and Telegraph (e.g., transmission division responsible for transmitter power systems), also have important responsibilities in the provision of energy sources. The government is aware of problems in the organization of energy responsibilities in the public sector and has presently decided to adopt a step-by-step approach to gradually improving the sector's organization. Meanwhile the fragmentation is likely to persist, and PV companies should become familiar with the various agencies whose activities have potential for PV application.

3.0 DEVELOPMENT PLANS

Morocco's economic planning periods are normally divided into five year cycles. However, to counter an overheated economy in 1976 followed by economic slump and worsening balance of trade deficits in 1977, Morocco's Fourth Development Plan was replaced by a three year transitional plan covering the period 1978 to 1980. This plan incorporated numerous austerity policies, such as import restrictions, higher import and other taxes, and credit restrictions, in order to increase revenues, reduce imports and lower the trade deficit. This plan has resulted in a relatively stagnant 3% growth rate in real national output, only keeping pace with Morocco's population growth.

The new five year development plan covering the period 1981 to 1985 is in the process of being revealed. Although no plan is available, the new plan is known to introduce greater stimulus into the economy, indicating somewhat of return to Morocco's earlier more capital-intensive and expansion-oriented development strategies. The expansionary emphasis has some important changes, however, from past emphasis on the modern industrial sector. Specifically, the new plan will encourage growth derived from labor-intensive projects, small and medium businesses, and more regionally widespread economic development in order to address unemployment and growing socio-economic and regional disparities. The expansion and diversification of exports is also a high priority. In its most important aspects, the plan concentrates on phosphate and derivatives production and export growth, the search for domestic energy resources to begin to displace soaring oil import costs, and the attainment of food self-sufficiency.

The plan covers only budget allocations, on which only partial information is available because of the immense difficulty in charting the flow of government funds through ministries and parastatal organizations and the poor accounting of changes in actual budget expenditures. However, the capital investment budgets for 1980 and 1981 (Table 3-1), serve as an indication of the shifts in the new plan. Specifically it shows a nearly 19 percent budget increase in capital investments.

TABLE 3.1

CAPITAL INVESTMENT BUDGET

Ministry	Budget (000 DH) 1980	Percent of Investment Budget 1980	1981	Percent of Increase 1980-1981
Agriculture (excluding dams)	1,503,000	9.2	15.0	93.4
Education	842,670	6.2	8.4	60.2
Public Health	237,710	1.5	2.4	83.8
Housing	205,427	1.5	2.1	64.8
Labor	78,540	0.6	0.8	54.9
Total Investment Budget	9,996,633	-	-	18.6

SOURCE: "Morocco: Agricultural Situation," Attache Report MO-10006, U.S. Embassy, Rabat, Morocco, Feb. 1981, p.39.

3.1 Agricultural Plans

The emphasis on growth in the new plan involves several sectors, and notably agriculture. Of a total capital budget of approximately $2.5 billion in 1981, agriculture accounts for 15 percent or nearly $400 million, up 93 percent from 1980. A goal recognized as not being wholly achieveable in the Plan period is food self-sufficiency, if not in each individual crop, at least to the point where revenue from food exports pays for food imports. The present situation where agricultural imports exceed exports is very bothersome to Morocco, an agriculturally based country. In support of agricultural growth, irrigation projects already commenced will be finished and some new ones started. An expansion of about 130,000 ha is planned for the nine major irrigation perimeters for the 1981-1985 plan period. Completion of these perimeters will increase the total irrigated area to about 680,000 ha.

More investment will be placed on dryland agriculture. The Hassan II Agriculture College has recently introduced new programs to increase the training of technicians in dryland disciplines. In addition most World Bank lending in recent years carries important components for dryland agriculture as well as credit to small growers.

Several other initiatives the Ministry of Agriculture and Agrarian Reform is taking in support of this sector are:

- The support price of cereals has been increased by 20 percent;
- Milk price has been increased by 15 percent;
- Rice prices were increased by 23 percent;
- The price of improved seed has been decreased and the supply has been increased by 55 percent;
- The taxes on tractors have been lowered by 15 percent:
- The price of fertilizer is remaining the same as last year;
- The amount of credit available for small farmers has been increased.

It is hoped that the effect of these combined activities will be substantially increased productivity throughout Morocco's predominant small-farm agriculture sector.

In addition, the Moroccan fishing subsector will be receiving economic development as well as increased diplomatic attention. In an attempt to boost the industry's competitive position against foreign offshore fishing fleets which are considerably better capitalized, investments will concentrate on modernizing the fishing fleet and extension of the 200 mile economic zone.

3.2 Energy Development Plans

The 1978-1980 three year plan emphasized the need to reduce Morocco's dependence on imported oil. This orientation will be pursued with greater vigor and determination in the 1981-1985 five year plan period. The Ministry of Energy and Mines has begun to put in motion a national energy policy which is likely to affect every aspect of the Moroccan economy during the next few years. This policy encompasses important activities to:

- intensify oil and gas exploration;
- develop Morocco's very large oil shale deposits;
- accelerate rural electrification, particularly with small and medium scale hydroelectric generation;
- extract uranium from phosphates and introduce nuclear energy;
- intensify exploration and production of coal, lignite and uranium;
- develop renewable energy, particularly solar energy and biomass; and
- encourage energy conservation.

The GOM has budgeted over $3 billion or DH 13 billion for the energy sector in the five year plan. This is compared to DH 4.4 billion for the two plan periods 1973-1977 and 1978-1980, reflecting the new importance of energy sector development. (See Table 3.2). About 44 percent is for electricity production and distribution and 36 percent for oil exploration, refining and distribution.

TABLE 3.2

INVESTMENTS IN THE ENERGY SECTOR

DH Millions

		1973-1977 Plan			1978-1980 Plan		
		Forecasts	Actuals		Forecasts		
		Amount	Amount	%	Brought Foward from previous plan period	Additional Funds	%
Coal		188	165	5	-	-	-
Oil Research		-	(519) 1/	16	-	331	27
	BRPM	-	343		-	-	-
	private	-	176		-	-	-
Petroleum Products 2/		-	(1149)	35	(225)	-	19
	refinery	400	858		225	-	
	distribution	-	291		-	-	-
Electricity	(ONE)	(1572)	(1364)	42	(73)	(564)	53
	production	-	895		71	416	41
	transmission	-	469		2	148	12
Rural Electrification 3/		-	19	1	-	8	1
Miscellaneous 4/		-	23	1	8	3	1
	TOTAL		3239	100	306	906	100

1/ Parentheses enclose sums for categories that have been further broken down.

2/ Funds for capital shares in refinery and distribution not included.

3/ Funds for Regional funds not included.

4/ Mining Research not included in particular for uranium.

SOURCE: Secrétariat d'Etat au Plan et au Développement Régional, Plan 1973-77 and Plan 1978-80.

This constitutes a very sizable increase in the rate of investment compared to the previous eight years, even taking into account the effects of inflation.

Oil and Gas Exploration

In oil prospecting, the GOM is now working with several international firms, French and American among them, in mainland as well as off-shore drilling in a number of regions, although, so far, with no major strikes. Work continues with support from the World Bank, which extended a $50 million oil exploration loan to Morocco in 1980. Currently there are six research and exploration agreements in force, two for terrestrial and four for off-shore between Morocco and foreign partners. The foreign partners include Apex, Phillips, Agrip, Getty and BP. As of June 1980, expenditures for oil and gas research totalled some $90 million by the Moroccan government and some $46 million by foreign partners[1/]. These expenditures have grown and will increase substantially in the new five year plan.

Oil Shale

Morocco is counting heavily on exploiting its oil shale resources, planning total investments of some $850 million (of $3 billion in all energy) in oil shale projects during the five year plan period. Cooperating with several American private firms, the GOM is experimenting with several different technical processes and plans to begin producing shale oil by 1983. It hopes to produce 100,000 tons by the "T3" surface pyrolysis retorting process. The GOM has made clear that it wishes to encourage private foreign investment to help develop its large oil shale deposits in the Middle Atlas mountains and Tarfaya in the south. In addition to extracting oil, the GOM plans to have the first experimental portion of a 1,000 megawatt shale-fired electric power generating facility in operation in Timahdite by 1985 with Soviet cooperation. By all processes (an "in situ" process is also under development), Morocco ambitiously hopes to be producing 2,100,000 tons annually of shale oil by 1990.

Coal

The leading project in the five year plan is the opening of additional facilities at the Jerada mine which will bring production of coal up to 1 million tons a year from the current 720,000 tons. The value of this investment is DH 165 million. Actual known reserves are estimated at 100 million tons, but are expected to be higher.

1/ "Monthly Information Review," Banque Marocaine du Commerce Exterieure, Casablanca, Morocco, No. 29, July-August 1980.

Electricity and Rural Electrification

Electricity demand is expected to continue to grow at an annual 9 to 10 percent rate to satisfy the increasing needs of the industrial sector and the urban and rural domestic sectors. Total installed capacity at the end of 1979 was 1.2GW, and with the completion of the Kenitra and Mohammedia Thermal plants during the 1981-1985 period capacity will total 2.1GW. Total consumption in 1980 was approximately 5,000 GHW, up from 4400 GWH in 1979.

Electricity is currently the responsibility of the Ministry of Energy and Mines. About 91% of the electricity consumed in Morocco is produced by the Office National de l'Electricite (ONE). Distribution in the major urban areas is handled by the regies (autonomous public enterprises under the Ministry of the Interior) and in other urban centers by ONE under the administrative supervision of the Ministry of Energy and Mines. In rural areas, so many ministries are involved in rural electrification that it has been necessary to set up an Interministerial Rural Electrification Commission, with the task of preparing the long-term government rural electrification program, implementation of which is entrusted to ONE.

The use of electricity in rural areas is still very limited; only about 7% of the population has electricity. Until now, electrification of rural regions has been hindered by the scattered location of villages and the high cost of distribution. The rural electrification program recently adopted by the government in cooperation with the World Bank will include a major expansion of hydro capacity, including small dams. It is expected to ultimately extend the grid to 1800 village centers in 17 provinces and increase the number of rural dwellers with access to electricity to 8% by 1984 and 10% by 1995. Thus there will still be large portions of the population unserved in the medium and longer terms, when PV is estimated to become competitive as a daytime electricity saver.

The present electricity tariff structure does not seem to encourage growth in the number of low-income users. Since electricity charges taper down as consumption increases, consumption by small users is charged at a relatively high average price. Hitherto the electricity rates for large-scale industrial users have been below ONE's average generation cost. A reform of the present tariff system is currently under study and these subsidies are to be eliminated in the near future.

Renewable Energy

The Moroccan government has already taken steps to explore the potential of renewable energies. Feasibility and preliminary design studies were carried out in mid-1980 for pilot projects in small decentralized hydroelectric generation, solar energy, biomass and wind energy, all under the auspices of a new Center for the Development of Renewable Energy being established in Marrakech with US AID financing. PV, small hydro and wind are particularly attractive to the government because of their potential for contributing to the development of remote, deprived areas in the context of Moroccan policy of reducing regional disparities in services. The Center has approximately $7.5 million in funding over the next four to five years.

Despite Morocco's serious search for import-substituting energy sources and an apparent enthusiasm for solar energy, it is clear that solar energy is largely thought of as "energy of the future", a research area, by those in central energy policy roles. The actual use of solar energy in the context of national development plans will not be realized during this plan period. However, "informal" development plans relating specifically to PV are beginning to take shape in a decentralized fashion at a number of agencies. These are agencies such as Ministry of Transport and Ministry of Post, Telephone and Telegraph which are considering PV systems specifically for remote power for TV telecommunications and signalling (discussed in detail in Chapter 7). Although distant from the formal plan process, these activities represent a positive practical approach to the use of PV systems by the public sector for national policy objectives.

4.0 FINANCING OF AGRICULTURE, ENERGY AND DEVELOPMENT PROJECTS

4.1 Overview of the Moroccan Banking System

Morocco has a well-established banking system made up of the Central Bank, Bank of Morocco (Banque du Maroc), 15 private commercial banks, and a number of specialized public and semi-public financial institutions. Together they provide a complete range of banking services to potential investors, with the specialized institutions becoming increasingly important for medium and longer term investments.

The Central Bank issues currency, regulates the money supply and supervises the banking system. The Central Bank manages the country's foreign reserves and is either buyer or seller in all foreign exchange transactions, via the commercial banks. The Central Bank is the major instrument for the implementation of monetary policy and the regulation of currency and credit. The Central Bank also provides commercial banks with rediscount facilities for certain types of credit, thus regulating commercial bank lending and investment by directing finances to those most needing assistance.

The 15 Commercial Banks, such as Citibank, Maghreb, are at least 50 percent Moroccan owned, and provide the usual services for their customers--loans, overdraft facilities, discount of trade bills, letters of credit and guarantees. Short-term credit (less than one year) accounts for about 65% of their credit. This consists primarily of commercial, industrial, and agricultural loans, overdrafts, and advances against inventory. A typical rate for overdrafts is 10.5% to 12.5%. Medium term financing accounts for only 10% of all loans and is slightly higher in interest. Long term financing is also available.

Maximum interest paid on time deposits is fixed by law and varies according to tenor, but is relatively low compared to rates available in the U.S. and Europe.

Specialized financial institutions play a large part in assuming credit selectively, or investment in specific sectors of the economy. Thus the National Economic Development Bank (Banque Nationale pour le Developpement Economique--BNDE) undertakes in particular the financing of industrial activities; the Building and Hotel Credit Company (Credit Immobilier et Hotelier--CIH) assists with loans for building and hotel construction; the National Fund for Agricultural Credit (Caisse Nationale de Credit Agricole--CNCA) is oriented towards the financing of both short term seasonal activities and real estate in agriculture, and the Deposit and Management Fund (Caisse de Depot et de Gestion--CDG) is a diversified public fund getting resources from savings banks and the social security system.

These institutions have grown rapidly in the past 7-8 years, specifically in providing medium and long-term credit to the economy.

4.2 Amount and Distribution of Credit

The total amount of credit provided to the private sector by the Moroccan banking system was DH 14.9 billion, in 1978. Two percent was provided by the central bank, 36 percent by specialized institutions and 62 percent by the commercial banks. Correspondingly, 38 percent of this total was medium and long-term credit while 62 percent was short term. The distribution to the private sector for the years 1973 through 1978, showing credit by sector, origin (type of bank) and maturity is shown in Table 4.1.

TABLE 4-1 DISTRIBUTION OF CREDIT TO THE PRIVATE SECTOR, 1973-78 1/
(MILLIONS OF DIRHAMS, END OF PERIOD)

	1973	1974	1975	1976	1977	1978
BY SECTOR 2/						
Commerce	980	1286	1411	1507	1708	1712
Mining & Industry 3/	1640	2176	2664	2926	3569	3626
Agriculture	608	699	916	1041	1131	1238
Construction	253	421	448	608	840	974
Tourism	187	193	207	200	194	277
Other	647	786	1407	1655	2373	2093
Non-classified	1175	1395	1803	2790	3292	4492
BY ORIGIN						
Deposit Money Bank	3649	4750	5957	6994	8416	9233
Specialized Cred.Instit.	1635	2033	2714	3471	4454	5424
Development Bank	..	515	893	1321	1910	2229
Agriculture Bank	..	604	740	905	996	1232
Constr. & hotels	..	673	815	1025	1314	1691
Other Credit Instit.	..	240	266	220	234	272
Central Bank	206	173	185	262	237	283
BY MATURITY						
Medium & long term	1603	1980	2720	3540	4629	5644
Short term	3887	4976	6136	7187	8478	9296
TOTAL	5490	6956	8856	10727	13107	14940

1/ Includes foreign claims.
2/ Based on the records of Service Central des Risques covering loans extended by all financial institutions except Caisse de Dépôt et de Gestion (CDG). Coverage is not complete as small loans (less than DH 50,000 and DH 100,000 after 1978) are not declared.
.. Not Available
3/ Includes Energy

SOURCE: Morocco: Basic Economic Report, Volume II: Statistical Annex, World Bank Report No. 3289-MOR, Washington, D.C., Dec. 30, 1980, p. 56.

The statistics showing the percentage breakdown of credit to the economy by the deposit banks and specialized institutions are as follows:

	1973	1975	1977
1. Breakdown by sector			
Agriculture	17.1	10.3	8.6
Mining and industry (includes energy)	29.9	30.1	27.2
Commerce	17.9	15.9	13.1
Construction	4.6	5.1	6.4
Tourism	3.4	2.3	1.5
Others	11.8	15.9	18.1
Unclassified	21.3	20.4	25.1
TOTAL	100.0	100.0	100.0
2. Breakdown by term			
Long and medium-term	29	31	35
Short-term	71	69	65

These statistics probably do not allow a complete picture of credit distribution by sector. For example, unclassified credit, consisting essentially of loans below DH 50,000, has grown to the extent that it distorts the data for the classified sectors' larger loans. This is a positive element, as it indicates that the credit needs of small entrepreneurs have gone down year by year for the past ten years. This can be interpreted in two ways: (a) the number of small farmers with access to credit has increased, and they have helped to swell the volume of unclassified credit; and (b) private capital expenditure in agriculture has declined. The former seems the most likely, bearing in mind what is known about the efforts of the Caisse Nationale de Credit Agricole to broaden its clientele.

4.3 Interest Rates

These are adjusted periodically with changing economic and financial conditions, but as of September, 1980 were as follows: Interest rates applied by the banks to each category of credit are fixed by the monetary authorities, but only as concerns their maximum and minimum values. Mobilisable debts arising abroad are discounted at a rate of varying from 4.5% to 6% annum; export credit finance costs from 5.5% to 7.7%, non-specified overdrafts from 8% to 10.5% and other non-mobilisable short-term credits are subject to the same rate as mobilisable credits of the same type but increased by 1%. Other variable interest rates are described below with specialized financial institutions.

Only special credits have a standard rate. This is the case for warrants (4.5% for "cereal" warrants and 5.5% for other) and for credits bearing the signature of the Caisse Marocaine des Marches (6.5%).[1/]

4.4 Specialized Institutions

The BNDE, or National Economic Development Bank, contributes to the economic development of Morocco by financing industrial investments, usually on a medium term basis. BNDE may extend credit directly or refinance commercial loans. It may also take equity participations of 10% to 25% in some ventures. BNDE also acts as a consultant providing assistance in feasibility studies, management, contract negotiations, and other technical matters.

The amount of the loan is limited to 50% of the total value of the programme approved by the bank (including working capital). Interest rates are curently fixed at 10% per annum on medium term credit loans (2 to 7 years), and at 11% for long term credit loans (more than 7 years) with a discount of 2% for certain types of investment (according to the investment code of 13th August, 1973).

BNDE has recently focused on small and medium sized industries, but it is also the bank most likely to consider financing innovative or new technology ventures. An official in the Department of Studies indicated interest in speaking with solar companies who would be interested in considering investment in a facility in Morocco.

The CNCA, or National Fund for Agricultural Credit, is the source of medium and long-term credit to the agriculture sector. This includes a variety of agricultural enterprises including farm machinery, livestock, buildings, property and irrigation systems. CNCA loans generally cover 70 percent of the purchase price, and there is no fixed maturity for the loan--it often corresponds to the equipment lifetime. CNCA has different rates for different classes of client, credit standing, etc. but interest charged is generally 30 to 40 percent less than prevailing commercial rates. A typical rate would be 8.5% interest on a medium term loan.

The CNCA, like other Moroccan banks, has had trouble attracting money into savings deposits because of the low interest paid on these. CNCA offers rates varying from 3% on savings deposits to 8% on 18 and 24 month deposits and bonds. Given these returns and inflation of 12 to 15%, farmers (as well as other potential

1/ "Monthly Information Review," Op. cit. No. 30, September-October 1980, p. 10

savers) tend to invest in more equipment, livestock or other real assets. Consequently CNCA is over 50% dependent on government provided capital and foreign borrowing, which may result in lower lending to the agriculture should CNCA's borrowing conditions become more expensive.

The CIH, or Credit Immobilier et Hotelier, grants construction loans and credit intended for the financing of tourist infra-structure within the country. The types of credit offered by this institution can be classified into three groups:

1) building loans for personal habitation or rent;
2) building loans for commercial premises, the development of building contractors, and the purchase of commercial building and apartments;
3) the "hotel credit" which includes mortgage credits and credits with pledges (for the purchase of furniture and equipment).

The statutory rate of interest for all these loans is 11% but discounts of 5% are accorded on hotel credit and building loans for personal habitation.

4.5 Conclusion

Morocco offers an extensive financial system capable of handling and, in fact, facilitating foreign investment. Numerous specialized institutions are able to provide preferential financing as well as experienced advice for investments in specific sectors. Medium and long-term credit is commonly available, although the past several years have seen financing constraints consistent with the government's austerity measures. Loans for small borrowers are difficult to obtain (such as small farmers). The financial system would be slightly negative or neutral to investments in new technology such as PV.

5.0 BUSINESS ENVIRONMENT

5.1 Overview

Morocco has a mixed economic system with both the public and private sectors involved in investment. Many activities are state-owned and controlled, such as phosphate production, utilities and transportation, and some have significant state involvement, such as various manufacturing ventures. However, private enterprise is strongly encouraged in commercial and industrial activities and fields such as mechanical and electronic equipment, textiles, food and chemicals are dominated by the private sector. While the government is the largest investor in the country, it maintains a policy of divesting itself of holdings in industrial enterprises when they are considered commercially viable.

The Moroccan government is also eager to encourage American investment and trade with Morocco because of good relations and a perception of superior quality in American technology and goods. Currently the U.S. holds 5th place in export trade to Morocco, with 6.5% or $260 million in 1980.[1/] The government offers Investment Codes which provide tax and other incentives to firms which invest in priority sectors of the Moroccan economy, of which energy is one. "Moroccanization" requirements for businesses, which have been somewhat clarified in recent years to allow easier investment access, and it is thought that solar energy companies may be eligible for 100 percent foreign ownership. In addition, labor rates are relatively low in Morocco, recently increased to the following:

- Min Guaranteed Industrial Wage: 2.35 DH/Hr = approx. $.50/Hr.
- Min Guaranteed Agricultural Wage:12.18 DH/day = approx. $2.55/day.

Despite little experience with solar energy, these policies should offer encouragement to PV manufacturers desiring to develop the Moroccan market or to establish an assembly type operation.

1/ "Monthly Information Review", Banque Marocaine du Commerce Exterieur, No. 34, April 1981, pp. 2-6.

5.2 Level of PV Public Awareness

Only about one-third of the individuals contacted had any substantial knowledge of PV systems. Among energy sector and telecommunications sector organizations the level of awareness was much higher, reflecting the great enthusiasm for solar energy in Morocco in general and the interest in photovoltaic development for specific uses, both tested and untested, in the country. Officials involved in irrigation, water pumping and rural refrigeration were also aware of possible PV applications. However, these individuals felt that the cost of PV precluded its adoption. They felt, however, that once PV costs declined to a level of competitive with diesel systems no cultural or social barriers would hamper its implementation.

Officials in telecommunications and transport signalling did not share these reservations about PV applicability, and several agencies are considering PV use in the near term. These include:

- Ministry of Posts, Telephone and Telegraph (PTT), Television Directorate - 1 KWp PV systems to power isolated television repeater stations for broadcast of TV signals to rural villages.
- Ministry of PTT, Transmissions Division - 3.6 KWp PV systems to power microwave relay stations for transmissions of phone, telex, and telegraph messages.
- National Railroad Office - 300 Wp PV systems to power flashing lights at rail crossings.
- Ministry of Transport, Director of Secondary Ports - 240 Wp PV Systems for light buoys and 2.4 to 6 KWp PV systems for lighthouses.
- Ministry of Transport, Air Directorate - 300 Wp PV systems to power pre-landing strip radio beacons.

Private sector contacts were not, generally speaking, familiar with photovoltaics (except, of course, representatives of PV companies). A number of contacts indicated they had seen photovoltaics, for example, at trade fairs and abroad, and some equipment distributors were familiar with PV systems through other distributors and literature. But the majority

of those who were aware of PV felt the costs were too high. Among farmers, awareness of PV was very low and many were skeptical about its ability to function. In particular, high first cost would be the principal inhibitor to PV use in the rural sector, since most farmers without access to electricity also lack the financial resources to purchase PV systems. Like the public sector, the private sector in Morocco is adopting a wait-and-see attitude towards PV.

Banking community contacts were similarly unfamiliar with PV technology and skeptical about its loan prospects. At the National Agricultural Credit Bank (Caisse National du Credit Agricole) portfolio directors and loan analysts termed PV "energy of the future" and mentioned that new technologies were not within their purview. However, they felt that if a borrower was able to meet normal loan criteria, primarily cash flow, there would be no specific barriers to PV financing. This attitude was reflected at other banks as well.

5.3 PV Business Activity

At present, there is no Moroccan production of PV equipment and only little production activity in other solar technologies, mainly water heating. However, a number of American and French PV companies have already initiated marketing efforts in Morocco, largely concentrating on water pumping applications. A number of important PV installations are operating in Morocco, mainly in commercial, public and military telecommunications (see Chapter 7), and have provided satisfactory service. These installations provide much of the current impetus for new PV purchases, with companies conducting their limited marketing activities directly to the responsible communications agencies.

While in Morocco the team contacted three firms which market PV equipment, two American and one French. All operate through Moroccan distributors, which are electrical supply companies and one pump distributor. The French company, Leroy-Somer, uses Photon Source (also French) photovoltaic cells in their modules. Leroy-Somer is currently planning PV demonstrations projects, primarily in water pumping applications. These will be conducted in cooperation with SIMEF, a quasi-public organization. If the demonstrations are successful, Leroy-Somer plans on setting up a module manufacturing plant in Fez.

Significant generator and motor fabrication and assembly under license from foreign manufacturers also takes place in Morocco. The major licenses are from Deutz (German), Petters, Lister and Rolls Royce (British), Leroy-Somer, Bernard Moteurs and Peugeot (French), and Worthington (American). The production of small diesel motors in the 4 Hp to 20 Hp range in Morocco amounts to 5,000-6,000 units annually (Petter and Lister licenses). Small gasoline motors (1.5 - 12 Hp) are in widespread use in Morocco, with 5,000 - 6,000 units sales annually, of which 2,000-3,000 are produced in Morocco. Table 5.1 shows 1980 generator imports. About 65 percent of these are in the range of 1.5 to 4 Hp. Increasingly small gasoline engines are being replaced by kerosene and diesel ones to take advantage of significant fuel cost savings (gasoline = \$3.10/gallon; diesel = \$1.65/gallon; kerosene = \$1.25/gallon). Some typical motor costs in Morocco are as follows:

- 1.12 KW AC Motor: \$175
- 6.24 Hp Diesel Engine: \$1,800
- 12.5 Hp Diesel Engine: \$2,200

These are average costs based on the most commonly used motors in use in Morocco for the applications under investigation.

5.4 Regulations and Tariffs

Morocco's Foreign Investment Code offers many advantages to potential investors, including exemption from customs duties and provision for attractive tax breaks. Moroccan law requires that a majority of seats on the board of directors be held by Moroccans. However, in such high priority sectors as mining (which includes conventional energy production), tourism and manufacture for export, one hundred percent foreign ownership is authorized, while still permitting foreign firms to profit from investment code incentives. With regard to solar energy, officials from the Ministry of Energy and Mines are currently seeking approval of an investment code favorable to solar businesses, but a determination is not expected for some time.

The Moroccan Government's Office of Industrial Development participates with equity capital in certain projects. Investment incentives offered

TABLE 5.1

MOROCCO GENERATOR IMPORTS 1980: TOTAL AND U.S.

	Value (DH)[a/]		Units	
	Total	U.S.	Total	U.S.
DC Motors and Generators	787,710	51,084	25,587	49
Other Motors and Generators, less than 10 Kg	1,743,587	25,214	30,201	78
Other DC Motors, more than 10 Kg	2,293,131	1,716,513	407	38
Electric Generator Sets	14,828,887	2,214,164	1,518	60
AC Generators	3,089,610	40,280	605	48
Low and High Frequency Generators	1,221,029	13,238	-	-

a/ \$1 = 4 DH at avg 1980 exchange rate.

Source: 1980 Import Statistics compiled by Banque Morocaine du Commerce Exterieur.

by the Investment Code to 50% Moroccan-owned firms include exemption from duties and taxes, liberal loans, and capital and dividends transfer guarantees. Even more favorable investment terms are available to firms locating operations in urban centers outside the dominant Casablanca-Rabat-Mohammedia industrial area. New investment with capital in excess of U.S. $6.4 million can negotiate additional incentives with the Moroccan Government. Local business registration requirements are complex and new businesses must apply for inclusion in the "Registre du Commerce" of the Ministry of Commerce and Industry and with the Ministry of Finance.[1/]

The Government is committed to improving its investment climate and is establishing a "centre d'accueil" to coordinate investment procedures. A U.S.-Moroccan Joint Committee for Economic Relations was established in 1980 and should lead to greater U.S. investment and exporting opportunities. Capital and dividends repatriation is assured through the U.S.-Morocco investment guaranty agreement. Morocco's tariff structure, based on Customs Cooperative Council nomenclature, maintains a two-column tariff structure with duties applying equally to imports from all countries. Ad valorem duty rates range from 30-40% on luxury goods and imports competing with locally produced item, to 5-25% on producer goods, fuels, raw materials and essential imports.[2/] Duty exemptions are available on machinery, equipment and supplies for a project when imported goods are to be re-exported. Import licenses are not required for about 75% of all imports.

5.5 Conclusions

American PV manufacturers face both advantages and disadvantages in trying to develop the Moroccan market. The principal advantages are that there is a genuine enthusiasm for PV and other solar technology, as well as relative awareness and knowledge of PV applications and advantages

---

1/ Parts excerpted from "Morocco: Worth Watching as It Enters the 80's", Unclassified report, U.S. Consulate General, Casablanca, 1980.

2/ "Foreign Economic Trends and Their Implications for the United States: Morocco", FET 81-022, U.S. Department of Commerce International Marketing Information Series, Washington, D.C., February 1981.

in some important sectors such as telecommunications and agriculture. In addition, a number of American PV companies are becoming active and establishing name recognition. Also Moroccan general business investment incentives are increasingly attractive and there is a stated policy of attracting American firms.

Disadvantages are important as well, and the most important have to do with PV cost-competitiveness (see Chapter 6 and 7) and the well-established market for conventional electrical generator equipment. No specific incentives exist for PV or solar companies, although some are under consideration. Long-term capital is scarce in Morocco, as is an overall awareness of PV systems. And American firms, although generally well-regarded, face keen competition from the French who are well-established in Moroccan private and public sector trading. Tariff import regulations present some confusion, although these are being progressively clarified.

6.0 AGRICULTURE AND RURAL SECTOR PV APPLICATIONS

This chapter discusses primarily agricultural and rural service power uses which were investigated for the possible application of PV in Morocco. It was found for most of these applications that PV use would be inappropriate in the near term for the following reasons:

- the power use itself will not be significantly established in the rural setting in the next five years;
- power use is likely to be located in grid-connected sites;
- or PV power will cost substantially more than diesel power in the specific application in the next five years.

It is important to note, however, that PV use could be feasible for some of these applications in the near term, such as small low-head irrigation pumpsets, due to localized factors. The market potential for PV is also expected to improve substantially in the mid and longer terms as its relative cost decreases.

For purposes of the life-cycle cost analyses in this and the following chapter, installed PV systems costs in Morocco are based on the calculations shown in Table 6.1 (no battery storage) and Table 6.2 (with batteries). The 1982 and 1986 PV prices in the U.S. are based on the JPL cost projections discussed in Chapter 1.

TABLE 6.1: COSTS IN MOROCCO OF AN INSTALLED 1KWp PV SYSTEM FOR WATER PUMPING (NO BATTERY CAPACITY)

(JULY 1980 DOLLARS)

	1980 Cost, $	1982 Cost, $	1984 Cost, $	1986 Cost, $
Total U.S. Cost	17,170[a]	8,050[a]	5,960[b]	3,870[a]
Sea freight (at $1/kg)	650	650	650	650
Distributor's margin (30%)[c]	5,150	2,420	1,790	1,160
Total initial cost	22,970	11,120	8,400	5,680
Present value of maintenance cost	260[a]	260[a]	260[b]	260[a]
Present value of life-cycle cost	23,230	11,380	8,660	5,940

[a] Appendix B

[b] Interpolated

[c] Over and above a U.S. distributor cost, which constitutes about 12% of the total U.S. price.

TABLE 6.2: COSTS IN MOROCCO OF AN INSTALLED 1KWp PV SYSTEM WITH BATTERIES[a] (JULY 1980 PRICES)

	1980 Cost, $	1982 Cost, $	1984 Cost, $	1986 Cost, $
Total U.S. Cost	20,850[b]	11,730[b]	9,140[c]	6,550[b]
Sea freight (at $1/kg)	650	650	650	650
Distributor's margin (30%)	6,250	3,520	2,820	1,960
Total initial cost	27,750	15,900	12,610	9,160
Present value of maintenance cost	3,060[b]	3,060[b]	2,680[c]	2,300[b]
Present value of life-cycle cost	30,810	18,960	15,290	11,460

[a] Battery capacity for 3-day operation; not including customs duties and sales tax.

[c] interpolated

[b] Appendix B

6.1 Pump Irrigation

The present situation: Presently about 720,000 ha are irrigated in Morocco, out of an irrigation potential of about 1,180,000 ha. The irrigated agriculture sector in Morocco comprises three subsectors:

(a) Nine major irrigated perimeters, each managed by a regional authority (ORMVA--Office Regional de Mise en Valeur Agricole), with a total irrigated area of about 550,000 ha at the end of 1980.

(b) Small and medium irrigation projects, managed by the PMH (Service de la Petite et Moyenne Hydraulique) of the Ministry of Agriculture and Agrarian Reform. In the last eight years this service has completed about 1700 ha, mostly by surface irrigation.

(c) Independent irrigation projects, mostly based on pumping from wells or water courses (oueds), which are managed either by private sector operators or by the SODEA (Societe pour le Developement Agricole) and the SOGETA (Societe pour la Gestion des Terres Agricoles), which administer formerly expatriate-owned farms.

Potential for PV Applications: An expansion of about 130,000 ha is planned for the nine major irrigation perimeters for the 1981-1985 plan period (completion of these perimeters will increase their total irrigated area to about 680,000 ha). However,

the size of pumping equipment on these projects is much larger than anything currently contemplated for PV applications. The PMH is involved mainly in surface irrigation projects, and expects to accomplish only on the order of 1000 ha in pumped irrigation over the next five to ten years, also in perimeters too large for PV use (typically over 100 ha each). The SODEA and SOGETA irrigated perimeters are also typically of this size. Thus the potential for PV irrigation in Morocco lies mainly in small (1-10 ha) irrigated farms operated by the private sector.

Production of pumpsets for small irrigation: The production of small diesel motors (4 to 20 HP) in Morocco amounts to 5000-6000 units annually of the Petter and Lister brands (under British licenses). No diesel motors are imported. The sales of small gasoline and kerosene motors (1.5-12 HP, of which about 65% are in the 1.5-4HP range which is too small for diesel) are also about 5000-6000 units annually. Of these, about 2500-3000 units are manufactured in Morocco (using some imported components) by Bernard Moteurs and the rest imported.[1/] About 85%-90% of all small internal combustion motors are used for agriculture and the rest for industry, construction, etc. Several pump brands (Alta, Ideal, Tubex) are manufactured in Morocco for use with these motors.

As for small (0.5-10HP) electric motors, about 7000-8000 units are produced annually by the SIMEF (the parastatal Societe des Industries Mecaniques et Electriques de Fes). Due to the limited reach of the rural electricity network in Morocco, only about 10% of these electric motors are used in agriculture.

In Moroccan agriculture, the large majority (well over 90%) of small stationary motors are used for water pumping. Practically the only other use, to a much smaller extent, is for grain milling. Except for the last two years, during which sales have probably declined because of price rises, the market for small motors has been growing at about 15% annually.

Crops irrigated: Small farmers use pumping mostly for vegetable irrigation, with some irrigation of citrus and deciduous fruits, as well as of some forage crops on dairy farms.

[1/] Owing to the high price of gasoline (approx. $3.10/gal), most gasoline motors are being currently converted (by simple carburetor and gas tank modifications) to kerosene, which costs approximately $1.25/gal.

Groundwater depth: The depth of the water table in Morocco is variable but always significant. In the main agricultural regions it is generally as follows:

- 15-20m in the Oujda area;
- 20-40m in the Khemisset area;
- 15-25m in the Casablanca plain;
- 30-40m in the Chichewa area;
- 15-60m (and increasing) around Marrakech;
- 10-15m around Agadir; and
- 30-40m in Laayoun

Pumping from oueds also involves level differences of 20-60m. Generally speaking, few wells in Morocco have a depth of less than 15m, and irrigation pumping is rarely performed at depths surpassing 40m.

Farm sizes: These are highly variable, but the small private irrigated farms which represent potential for PV irrigation are generally in the 2-10 ha range.

Diesel motor sizes: The most popular size for irrigation are the 6.25-8.2 HP motors (6.25 HP at 1500 RPM to 8.2 HP at 2000 RPM) and the 12.5-16.4HP motor (12.5 HP at 1500 RPM to 16.4 HP at 2000 RPM). For long life, operational speed should not exceed 1500-1800 RPM; thus these motors will be referred to as the 6.25 HP and the 12.5 HP motors. The 6.25 HP motor is generally used at groundwater depths of up to 15m and the 12.5 HP motor at over 20 m depth. The 6.25 HP motor produces about 30 m^3/hour (8.3 l/second) at about 15m groundwater depth (20m dynamic head, including losses); the 12.5 HP motor should yield about 8.3 l/s at about 35m groundwater depth (40m dynamic head).

The irrigation season: Partial irrigation is necessary in April; full irrigation in May to September; and partial irrigation again in October and November. Thus in Morocco the irrigation season coincides with the period of maximum insolation.

Irrigation hours: Generally speaking, irrigation is practiced for about 5 hours per day: 2-3 hours in the morning and 2-3 hours in the evening. Farmers usually refrain from irrigation during the hours of maximum sunshine.

Irrigation mode: Small farms use almost entirely traditional surface irrigation. Very few use sprinkler or drip irrigation. On farms of the size considered, the pumpset is operated by the farmer or farm workers, not by specialized operators. Operation consists of refueling, startup and periodic adjustments. Thus the work involved is minimal and (unlike some other uses,

e.g., water supply or TV repeater stations) operator's wages should not be imputed as a cost to a diesel system when compared with a PV system. Irrigation normally takes place directly from pump to ditch without using an accumulation basin.

PV--Diesel Comparison: The comparison of diesel and PV irrigation systems is performed with the following conditions assumed:

(a) The comparison was undertaken between a 6.25HP diesel pumpset delivering 30 m^3/hr from a groundwater depth of 15m (dynamic head of 20m) for five hours daily and a PV system with the same water yield.1/ At a maximum field water consumption of 7.5 mm/day (including losses), either system can irrigate 2 ha.

(b) Overall (motor, belt and pump) efficiency was taken as 50% for both systems. Note that this implies a requirement for a total power of 4.4HP (3.3KW) only. For a diesel motor, a 6.25 HP installation is necessary owing to startup engine requirements; the electric motor associated with a PV system has better torque characteristics, so that a 3.3 KW motor and PV array is required.

(c) Since irrigation is most intensive in the high-insolation season, five hours-equivalent of peak sunlight are calculated for the PV system instead of the yearly average of 4.0 hours.

(d) Since the hours of maximum sunlight do not coincide with irrigation hours, the PV system will require a one-day accumulation basin capacity (150 m^3).

The economic feasibility of PV for irrigation is shown by the comparison of life-cycle costs in Table 6.3 (diesel) and 6.4 (PV). This comparison shows that even at 1986 PV prices (predicated on a cell cost of $0.70/Wp, plus other costs which bring the total installed cost to $3.87/Wp, life-cycle costs of the PV installation will be $23,600--nearly double the life-cycle cost of a diesel pumpset, which is $12,080. In addition, this analysis favors the PV equipment by assuming for it a July 1980 cost base, with no customs duty, and a local distributor's margin of 30% (which is minimal in view of the small orders involved). Furthermore, the diesel pumpset offers the farmer:

(a) operational flexibility--he can operate the diesel longer than 5 hours/day and expand his irrigated area, which is impossible with a PV system;

(b) financial flexibility--his front-end costs are $1800 for the diesel pumpsets, as compared with $22,000 for a PV array with motor, pump and reservoir; and

---

1/ Comparison with a 12.5 HP diesel pumpset (for a 40m dynamic head) would be less advantageous to a PV system, owing to the economies of scale of the 12.5 HP diesel pumpset.

TABLE 6.3: MOROCCO--LIFE CYCLE COST OF A 6.25 HP DIESEL MOTOR FOR IRRIGATION[a]

Item	Initial Cost $	Discounted[b] Cost $
6.25 - 8.2 HP diesel motor (air cooled) w/pump	1800	1800
Overhaul after 3 years (60% of purchase price)	1080	710
Overhaul after 5 years (including value seat change--70% of purchase price)	1260	600
Overhaul after 8 years (70% of purchase price)	1260	410
Replacement after 10 years	1800	440
Overhaul after 13 years	1080	180
Overhaul after 15 years	1260	150
Overhaul after 18 years	1260	100
Check of injectors and injection pump--($60 every 15 months)	50/yr	360
Diesel fuel (1.5 l/h at 1981 cost of $0.42/$l$ plus $0.03/$l$ transport charge, for 1000 hours/yr)[c]	675/yr	5750
Oil change, 2.51 each 100 hours at $1.65/$l$, with filter[c]	67/yr	570
Present value of life-cycle costs if installed in 1981		11,070
Present value of life-cycle costs if installed in 1986[d]		12,080

---

[a] Morocco April 1981 prices, not including 15% sales tax

[b] At a 15% discount rate, and 20 year analysis lifetime

[c] Fuel and oil assumed to have a real cost escalation rate (above the general inflation rate) of 3%.

[d] Taking into account the higher real fuel and oil costs projected for 1986

TABLE 6.4: MOROCCO--LIFE CYCLE COST OF A 3.3 KWp PV ARRAY WITH PUMPSET FOR IRRIGATION[a]

Item	Initial Cost, $	Discounted[c] Cost, $
Electric DC 5 HP (3.7 KW) motor, with pump[b]	860	860
Motor replacement, year 5	700	400
Motor and pump replacement, year 10	860	240
Motor replacement, year 15	700	100
150 m^3 reservoir (for 1-day operation)[d] (minimal cost)	2400	2400
Total, pumpset and reservoir life-cycle cost		4000

Year	1980	1982	1984	1986
3.3 KWp array, life cycle cost (Table 6.1)	76,660	37,550	28,580	19,600
Pumpset and reservoir life cycle cost	4,000	4,000	4,000	4,000
3.3 KWp array w/pumpset, life cycle cost	$80,660	$41,550	$32,580	$23,600

[a] Economic costs (15% sales tax on all items and 34% customs duty on PV systems were excluded).

[b] Motor cost assumed $700--double the cost of an equivalent 1500 RPM AC motor, to reflect the inherently higher manufacturing cost of DC motors and the cost of special importation.

[c] At a 15% discount rate.

[d] Rustic, partially excavated stone-and-mortar construction.

(c) risk reduction--diesel motor repair facilities are available in Morocco even in small towns, while a malfunction in the PV array or its DC motor would need expertise and spare parts from Casablanca or abroad.

Conclusion: Under these circumstances, it is unlikely that any private operator would opt for PV irrigation in the foreseeable future unless it were heavily subsidized. A subsidy policy is difficult to justify on national economic grounds and is unlikely to occur. The main barrier to PV irrigation in Morocco is the groundwater depth, which at 15 to 35m is simply too deep for economic PV operation.1/

6.2 Livestock Watering

The present situation: The 1980 livestock population of Morocco was estimated as 14.2 million sheep, 6 million goats, 3.4 million cattle and 300,000 horses. Morocco counts 20 million ha of natural pasture land, but over-grazing is a widespread national problem. The development policy of the Livestock Directorate of the Ministry of Agriculture and Agrarian Reform is centered on provision of water points, access roads and fences; there are also plans to create some irrigated pastures. A priority zone for these activities is Ein Beni Mehtar in the Oujda region (back of the Atlas range), where a USAID-assisted project has created one 10,000 livestock perimeter with four water points, and another perimeter is planned. Groundwater depth in this area is 15-20m. Another zone of activities is the Ouled Bou Shaa perimeter near Chichewa (in the Marrakech area), which had 25 boreholes completed in December 1978 by the Hydraulics Directorate of the Ministry of Equipment, with a total capacity of 350 l/s. Of these boreholes five are dry, five weak (1-2 l/s), five medium (4-20 l/s) and ten important (20-100 l/s). Water table depth is 55-75 m. It is planned to utilize these wells to their maximum capacity for irrigation of 400 hectares, for village water supply, and for cattle watering. The modest budget of the Livestock Directorate, however, permits it to undertake only very limited activities. As an indication, the above-mentioned boreholes have not yet been equipped with pumpsets, and the Livestock Directorate plans only about one deep borehole and two shallow (less than 30m) wide-diameter wells annually. In addition, private sector herders continue with the existing wide-diameter wells

1/ Another study using assumptions favorable to PV (a 10% discount rate), concluded that at $4/Wp PV would break even with diesel for pumping at a head of 4m. Smith, D.V. Photovoltaics in the Third World. Working Paper Number MIT-EL79-045WP, MIT, August, 1979.

and normally do not invest in constructing new wells or boreholes, or in equipping them with pumps for livestock watering.

Water point capacity: The maximum animal water requirements in Morocco in the summer, when temperatures are highest and the feed is only dry straw, is estimated to be up to 8 ℓ/day for sheep and goats, and 60-80 ℓ/day for cows. The carrying capacity of the natural pastures is about 1 sheep per hectare. A sheep should optimally not walk more than 2.5 km to the water; within a 2.5 km radius there are about 1960 hectares. Thus the required capacity of a water point is about 1960 x 8 = 15,680 ℓ/day. For a PV pump working during the summer the equivalent of 5 peak hours per day, the discharge must be 0.9 ℓ/s. Assuming 50m groundwater depth (typical for livestock-watering boreholes), 5m friction losses and an efficiency of 50%, the required array capacity is 1.0 KWp.

Advantages of PV power: PV power is ideally suited for livestock watering for the following reasons:

(a) livestock water requirements increase in the summer, as does the PV power production;

(b) when the sky is too cloudy for PV operation, it normally rains and the livestock can seek water in surface depressions, so that the required reservoir capacity is minimal;

(c) the small discharges mean that a diesel motor (usual minimum size = 6HP) is under-utilized;

(d) the water points are usually located at remote places where diesel motor refueling operation and maintenance pose serious problems.

Comparison with wind power: It should be noted, however, that most of the above advantages are also shared by the common windmill pump. Like the PV pump, the windmill pump requires a relatively large initial investment, but no fuel and operation costs and very little maintenance. Nevertheless, windmill pumps have not thrived in Morocco. Of the many thousands installed in the past, the large majority has been allowed in the last 25 years to fall into disrepair. This experience is thought by some to be applicable to PV livestock watering pumps because of unfamiliarity with the technology.

Costs of PV power: Table 6.5 shows that the present value of the life cycle cost of a 1 KWp PV installation with the appropriate electric pumpset

TABLE 6.5: MOROCCO--LIFE CYCLE COST OF A 1 KWp ARRAY WITH PUMPSET FOR LIVESTOCK WATERING[a]

Item	Initial Cost, $	Discounted[d] Cost, $
Electric DC 1.12 KW motor, with pump[b]	450	450
Motor replacement, year 5[c]	350	200
Motor and pump replacement, year 10	450	130
Motor replacement, year 15	350	50
Total, pumpset life cycle cost		830

Year	1980	1982	1984	1986
1 KWp array, life cycle cost (Table 6.1)	23,230	11,380	8660	5940
Pumpset, life cycle cost	830	830	830	830
1 KWp array w/pumpset, life cycle cost	$20,060	$12,210	$9490	$6770

[a] Economic costs (15% sales tax on all items and 34% customs duty on P/V systems were excluded).

[b] Motor cost assumed $350--double the cost of an equivalent 1500RPM AC motor, to reflect the inherently higher manufacturing cost of DC motors and the cost of special importation.

[c] Due to its small size, motor life is estimated at 5 years.

[d] At a 15% discount rate.

is projected as $12,210 in 1982, diminishing to $6,770 in 1986 (both in July 1980 dollars). Of the total costs, only $830 is associated with the pumpset and the rest with the PV array.

Costs of a diesel pumpset: The alternative to a PV pump in this use would be a diesel pumpset. In Morocco the smallest diesel pumpset in general use is the one generating 6.25 HP (at 1500 RPM) to 8.2 HP (at 2,000 RPM). At 50% overall efficiency, this pumpset would produce 3.1 l/s at a 55m dynamic head and would furnish the 15.68 m^3/day required by the cattle in 1.5 h/day. Such partial operation is typical of livestock-watering pumpsets. The pump will be operated by the livestock herder as a part of his normal duties. Water tank size will normally be sufficient for a 3-day operation, as in the case of a PV pump. Table 6.6 shows the present value of life-cycle cost of such a diesel pumpset, if installed in 1986, to be about $7,160.

Comparison of diesel and PV costs: The above analysis shows that PV will become competitive with diesel for livestock watering at about 1986. Note that the analysis has been skewed in favor of PV on the following points:

(a) The diesel pumpset and fuel have been costed at current (May 1981) prices, but the PV array in constant July 1980 dollars.

(b) The PV unit costs calculated on the basis of 20KWp-100KWp systems (Tables B.1 - B.3) were used (Table 6.1) for a 1 KWp system.

(c) Pumpsets and PV array were costed at economic costs (i.e., without the 15% sales tax and the probable customs duty on PV arrays); on the other hand, fuel and oil were costed at their market prices, which in Morocco include certain taxes. A financial analysis on the basis of market prices will make the PV alternative less attractive.

(d) The assumed 30% distributor margin may be too low.

Conclusion: Given the above factors, it is concluded that the market for PV for cattle watering in the next five years in Morocco will be insignificant. The basic reasons are:

(a) unless the Livestock Directorate considerably expands its well-installation activities, the entire potential market will be only a few pumpsets per year;

(b) most wells installed by the Livestock Directorate will be for combined livestock and irrigation use, so that the discharges will be much larger than in the above analysis and the PV alternative correspondingly less attractive;

(c) even in the case of a dedicated livestock well, PV will not become marginally cost-effective until 1986 or later. However, for water depths less than 50 m, PV will be cost effective sooner (e.g., a PV system for a 25 m depth well will be cost effective by about 1984).

TABLE 6.6: MOROCCO--LIFE CYCLE COSTS OF A 6.25 HP DIESEL MOTOR FOR LIVESTOCK WATERING[a]

Item	Initial Cost, $	Discounted[b] Cost, $
6.25 - 8.2 HP diesel motor, w/ pump	1800	1800
Overhaul--year 5	1080	520
Replacement--year 10	1800	510
Overhaul--year 15	1080	130
Check of injectors and injection pump ($60 every 30 months)	25/yr	180
Diesel fuel (1.5 l/h at 1981 cost of $0.42/l plus $0.03/l transport charge, for 550 hours/yr)[c]	370/yr	3150
Oil change, 2.5l each 100 hours at $1.65/l w/filter[c]	37/yr	320
Present value of life cycle costs if installed in 1981		6610
Present value of life cycle costs if installed in 1986[d]		7160

[a] Morocco April 1981 prices, not including 15% sales tax.

[b] At a 15% discount rate.

[c] Fuel and oil assumed to have a real cost escalation rate (above the general inflation rate) of 3%.

[d] Taking into account the higher real fuel and oil costs projected for 1986. Pump is operated by the herder as a part of his normal duties.

It should be emphasized however, that of all motorized PV applications, livestock watering--along with pumping from very shallow depths as is typical in delta areas--are the applications which make most economic sense. These two applications will generally become cost-competitive about 1985-1987, depending upon the particular situation. Even then PV will not find a large market in pumping for livestock watering in Morocco primarily because of the limited construction of water points for livestock.

6.3 Village Potable Water

The present situation and institutional framework: In Morocco, village potable water projects are financed by the Rural Affairs Directorate of the Ministry of Interior, which allocates to village councils (collectivities locales) budgets for water supply and other rural infrastructure projects. The rural infrastructure (amenagement rural) division of the Ministry of Agriculture and Agrarian Reform performs the programming and design of rural potable water works and supervises their construction. The village councils pay for the water works with the funds obtained from the Ministry of Interior, and assume responsibility for their operation. The ONEP (Office National de l'Eau Potable) is the central agency in the water supply field in Morocco; however, its activities are limited mainly to producing potable water and supplying it to the municipalities of urban centers and small towns; it is not active at present in rural water supply.

There were 150 rural water works programmed for the 1978-1980 three-year plan. Of these, 117 were completed and 33 are in various stages of progress. This high percentage (over 80%) of plan execution indicates the increasing attention which the Government of Morocco is paying to rural water works.

Planned Activities: The rural infrastructure division has proposed a program for the 1981-86 plan period. These will furnish a total discharge of 1675 l/s (to approximately 500,000 beneficiaries) and have a total installed motor capacity of 2032 KW. About 30% of the proposed units are electric and 70% are diesel-powered. The rural infrastructure division will present this draft program to a committee comprising ONEP, Ministry of Interior and Ministry of Agriculture representatives. The program, as modified and approved by the Committee, will be submitted by the ONEP to the Ministry of Plan for inclusion in the 1981-86 national five-year plan. Assuming that about 80% of the draft program will be retained, the five-year plan will include about 190 rural water works with a total installed power of about 1600 KW, of which about 1140 KW will be diesel power.

Water supply standards: Rural water works are calculated on the basis of 50 lcd (liters per capita-day) in 1980, increasing to 70 lcd in the year 2000 (the planning horizon). At the same time, the rural population is calculated to increase at 3% annually. Thus the potable water requirements of a given village are calculated to increase 2.53 times over the planning period.

Technical parameters: The pumping depth ranges from 10m to 100m and averages about 50m. The average project will pump about 7 l/s and have an installed capacity of 8.5 KW (not including standby capacity). The cost comparison between a PV powered system and a diesel motor is performed with the following conditions for this average project. It is assumed that the project will work 10 hours/day, supplying 252 m^3/day (sufficient for a village with a present population of 2000). Both the diesel and the PV project will be provided with a standby diesel pumpset, so that its cost does not enter the comparison. Since water supply projects are a public good, a comparision of economic costs is appropriate; thus the analysis excludes the customs duty and sales taxes on PV equipment, electric motors and diesel engines. Notwithstanding, the analysis used the sale price of diesel fuel which includes taxes, giving a slight advantage to PV.

Costs of a PV system: To pump 7 l/s from a water depth of 50m plus about 5m friction losses for 10 hours/day at a total motor/pump efficiency of 50% requires 75.5 KWH. At 4 KWH/day per KWp, this would require an array of about 20 KWp and, correspondingly, a 20 KW DC motor. Battery capacity is not necessary since the motor will be working during sunlight hours and the water stored. On the other hand, a water storage capacity for at least three days will be required, compared with the one-day capacity normally provided for diesel systems. This amounts to an extra 500 m^3 of storage capacity required. Table 6.7 shows that under these assumptions, the life-cycle cost of a PV system in 1986 will be about $131,000.

Costs of a diesel system: To pump 7 l/s against a dynamic head of 55m at a total motor/pump efficiency of 50% requires 10 HP. Due to the startup torque required, the motor size actually used will be a 12.5-16.4 HP motor (12.5 HP at 1500 RPM to 16.4 HP at 2000 RPM). In the first year (2000 inhabitants at 50 lcd), the installation must work only 4 hours/day, increasing gradually to 10 hours/day at year 20 at an average growth rate of 4.7% annually. It is assumed that the real fuel price escalation is 3% annually (IBRD estimate).

TABLE 6.7:

MOROCCO--LIFE CYCLE COST OF A 20 KWp PV ARRAY W/MOTOR FOR A POTABLE WATER SYSTEM

Item	Initial Cost, $	Discounted[b] Cost, $
Electric DC 20 KW motor	2750[a]	2750[a]
Motor rewinding after 5 years	550	315
Motor replacement after 10 years	2750	780
Motor rewinding after 15 years	550	75
$500 m^3$ extra reservoir capacity (minimal cost)[c]	8000	8000
Total, pumpset and reservoir life cycle cost		11,920

Year	1980	1982	1984	1986
20 KWp array, life-cycle cost (Table 6.1)	464,600	227,600	173,200	118,800
Pumpset and reservoir, life-cycle cost	11,920	11,920	11,920	11,920
20 KWp array w/pumpset and reservoir, life cycle cost	476,520	239,520	185,120	130,720

[a] Assumed double the cost of an equivalent AC motor, to reflect the inherently higher manufacturing cost of DC motors and the cost of special importation.

[b] At a 15% discount factor.

[c] For a rustic, partially excavated stone-and-mortar construction (a sheet-iron reservoir would cost about $25,000).

The PV system can be unattended, so that the diesel motor operator's wages are an extra cost of the diesel system. With these assumptions, Table 6.8 shows that the life-cycle cost of a diesel system will be about $40,000.

Comparison of the PV and diesel systems: The above figures indicate that the life-cycle cost of a 20 KWp PV system for potable water installed in 1986 will be about three times that of a comparable diesel system ($131,000 vs. $40,000). The front-end costs will be about $124,000 for PV vs. $2200 for diesel. Under these circumstances, PV use for potable water pumping will not be economically feasible. It is unlikely that the additional reliability offered by the PV system will compensate for the large cost difference.

PV barriers and issues: A barrier to PV use for potable water in Morocco is that, due to the relatively incipient stage of the rural water supply network, systems are now being constructed for communities with an average present population of 2000 inhabitants. In these rather large systems, the economies of scale are not favorable for PV. Water for smaller communities is presently supplied by spring captures or by installing a used wind pump (of which there exists a plentiful supply). PV is not competitive with these systems either.

Since water demand gradually increases through time, PV costs could be reduced by installing only a smaller array immediately. In the average project calculated above, installing only one 10 KWp array at the beginning and another 10 KWp array after five years would furnish the required water quantities while reducing the present value of life-cycle costs from $131,000 to about $102,000. This, however, is still 2.5 times the life-cycle cost of the comparable diesel system.

6.4 Grain Mills

The present situation: Grain mills are the only other significant use for stationary power sources in Morocco and account for a few percent of the approximately 5000 diesel motors sold annually. Such a mill normally uses a 12.5 - 16.4 HP diesel motor, grinds 14kg of grain per hour and works about 7 hours per day (10-12 hours on market days). The cost of the mill (excluding the 15% sales tax) is about $1200, plus $2200 for the associated motor.

Reasons for not considering PV use: The economics of PV for grain milling are considerably worse than for pumping. This is due to the necessity to work in the winter and the longer working hours, requiring a larger array capacity per installed HP, and battery capacity. Assuming a load of 6.7 KW during

TABLE 6.8:

MOROCCO--LIFE CYCLE COST OF A 12.5 - 18.3 HP DIESEL MOTOR FOR A POTABLE WATER SYSTEM[a]

Item	Initial Cost, $	Discounted[b] Cost, $
12.5 - 18.3 HP diesel motor	2200	2200
Overhaul after 3 years (60% of purchase price)	1320	870
Overhaul after 5 years (70% of purchase price)	1540	1080
Replacement after 8 years	2200	720
Overhaul after 11 years	1320	280
Overhaul after 13 years	1540	250
Replacement after 16 years	2200	240
Overhaul after 19 years	1320	90
Salvage value after 20 years	(1400)	(90)
Check of injectors and injection pump ($60 every 15 months)	50/yr	360
Diesel fuel (3 l/h at 1981 cost of $0.42/l plus $0.03/l transport charge, for 1460 h/yr at year 1 increasing to 3650 h/yr at year 20)[c]	$1970/yr to $4930/yr	22,900
Oil change,[c] 4 l each 100 hours at $1.65/l, w/filter	10% of fuel	2290
Operator ($100/month, at half-time)	1200/yr	4320
Present value of life cycle costs if installed in 1981		35,510
Present value of life cycle costs if installed in 1986[d]		39,540

[a] Morocco April 1981 prices, not including 15% sales tax.

[b] At a 15% discount rate

[c] Fuel and oil assumed to have a real cost escalation rate of 3%.

[d] Taking into account the higher real fuel and oil costs projected for 1986.

a 42-hour work week, 4 hours-peak equivalent of insolation per day in winter, and a (minimal) 3-day battery capacity, the required array size will be 10 KWp and 1986 array life-cycle cost alone will be $114,600 (Table 6.2). Thus PV use in milling would occur considerably later than in pumping.

6.5 Highway Intersection Lighting

The present situation: The Highway Directorate is interested in improving the security of driving on the major highways. One of the measures contemplated is the illumination of intersections.[1/] Priority roads for improvement are the Rabat-Casablanca freeway and coast road (about 92 km each), the Rabat-Kenitra road (40 km), the Rabat-Fez road (198 km) and the Agadir--Ait Melloul road (13 km). According to road maps, these roads have about 30 isolated major intersections. The number of intersections to be improved will be determined by a feasibility study which the Highway Directorate plans to commission in the near future.

Lighting requirements: To furnish a road-level lighting intensity of 24 lux/m^2, each intersection will be equipped by six to ten lampposts of two 125W fluorescent lamps (or two 250W incandescant lamps) each. Thus the total power required per intersection (with fluorescent lighting) is about 2 KW. This lighting is required for about 10 hours daily, from 7p.m. to 5a.m.

Economics of PV: The only practical alternative to PV power in this application is an extension of the electricity grid to the intersection to be lighted. The cost of a 13.2 KW line is about $9000/km, plus about $2000 for a 10KVA transformer and $0.08/KWH for the electricity. At an average power production of 4KWh/day per KWp and a 10-hour/day operation, each intersection would require a 5 KWp PV installation. Based on Table 6.2, the life-cycle cost of the PV installation and the break-even distance (the distance from the grid at which PV power becomes competitive) are as follows:

TABLE 6.9

COST COMPARISON OF PV AND GRID EXTENSION FOR HIGHWAY LIGHTING

Year	1980	1982	1985	1986
Life-cycle cost of a 5 kwp installation, $	154,000	94,800	76,500	57,300
Break-even distance, Km	17	10	8	6

1/ On the other hand, the installation of flashing red and yellow lights on inter-urban highways is not proposed.

Reasons for not considering PV use: The above cost comparison shows that during the coming five years the break-even distance for PV highway lighting will be 10 to 6 km. Most of the intersections to be lighted are within that distance from the grid. An extension will also bring the grid that much closer to neighboring villages which need electrification, whereas a PV installation lights the intersection only. Thus it is unlikely that the Highway Directorate will find PV economical in the coming five years. The subject should, however, be investigated with greater precision during the proposed highway improvement feasibility study.

6.6 Educational Television

The present situation: The average literacy rate in Morocco is about 46 percent, and in rural areas it is considerably lower. Educational TV could make a significant contribution to increasing the literacy rate. However, at present educational TV programs are limited to three half-hour evening broadcasts weekly, which are aimed at increasing the educational level of primary school teachers. Plans for educational TV programs aimed directly at school children are still at an embryonic stage.

Reasons for not considering PV: At present, TV broadcasts on weekdays start at 6:00p.m. The installation of an educational TV channel would signify considerable additional expense for daytime broadcasts, which at present are not planned. Unless the Moroccan educational policy embarks on a major effort in educational television, it is not considered likely that in the coming five years there will be a significant demand for PV systems to power school TV sets in remote locations.

6.7 Veterinary Extension Posts

System characteristics: Those provinces of Morocco which have an important livestock population are served by the veterinary extension system. Veterinary agents are located at the district[1/] centers; from these posts they periodically travel the surrounding villages on vaccination campaigns. The vaccines used in these campaigns need refrigeration to remain effective.

Reasons for not considering PV use: The agents are lodged at district centers, which have electricity. They go out for the day and normally return

1/ Cercle, the administrative division below the province.

to their post in the evenings. Agents carry the vaccines in thermos containers, which are refilled with ice before every trip. Thus the veterinary extension system does not need PV systems to power refrigerators in locations which do not have electricity.

6.8 Cold Storage for Fish

The present situation: The major fishing ports of Morocco are equipped with electricity, which can power cold storage facilities. However, about 5000 small craft (about half of them equipped with outboard motors and the rest with oars only) operate out of over fifty small harbors and beaches along the coasts. The fishermen of these feluccas store their catch in the open air until an intinerant truck driver carries it to the market, often with considerable spoilage. In principle, cooperative cold storage facilities would benefit such fishermen.

Reasons for not considering PV use: The organization of local fishermen into cooperatives is still at a very early stage, and ONP (National Fishing Authority) efforts in this direction are quite limited. Thus there is in Morocco no group of fishermen sufficiently organized to undertake the acquisition and operation of cold storage facilities. In addition, installing cold storage on a remote beach for resale of small quantities of fish to passing trucks is not an activity which appeals to private investors. It is significant in this respect that even the installation of simple ice boxes--which could be restocked with ice blocks by the trucks on their return from major markets--has not been undertaken so far. In these conditions, the installation of expensive PV powered refrigeration facilities in small fishing ports during the next five years seems premature. It is noteworthy that a project by the Public Works School to install a 2 m^3 solar-powered cold storage facility near Agadir has been discontinued.

7.0 OTHER PV APPLICATIONS

This chapter discusses the applications for which an effective demand for PV already exists in Morocco or is likely to develop in the near and medium terms. It describes the use characteristics in these applications, the potential market size, and the conditions which PV systems should fulfill to realize this potential. Except for refrigerators for rural clinics, the PV applications considered feasible in Morocco over the next five years are in the areas of telecommunications and transportation.

7.1 Rural TV Receivers

The present situation: There are currently in Morocco about 1,000,000 TV sets, and this number increases by about 7.5% annually. The Television Directorate estimates that only about 1% of this number, or very roughly 10,000 sets, are used in rural locations which have no source of electric power and are operated by batteries which must be taken weekly to the market for recharging. However, the Television Directorate believes that if PV-powered television sets (PV-TV) were widely available at a reasonable price, the above numbers could grow substantially very rapidly.

The economics of PV: A 12" black-and-white TV set consumes from 15 to 45 watts. TV sets currently marketed in the U.S. as part of PV-TV packages consume 20 watts. Assuming operation of 4 hours per night, a 20 watt TV could be operated by a 20 Wp panel(at 4 W-hours per Wp). Assuming a 1980 price in Morocco of $35/Wp for the module and switchgear, excluding battery ($22.97/Wp installed in Morocco as per Table B.1, plus 34% customs duties and 15% sales tax), a PV module would cost about $700. At 1982 prices of $11.12/Wp plus duties and taxes, the total cost would be about $340. Assuming that the alternative is weekly battery recharges at a cost of $4 each, the PV module would pay for itself in about two to three years even at present PV prices. Convenience and prestige would be two other reasons working strongly in favor of PV-powered home TVs in rural areas.

The market for PV: For want of more concrete market information, it is assumed that if a reasonably priced PV-TV system were available, over the next five years (a) half of the estimated 10,000 battery-operated TV owners would adopt it, and (b) the rate of acquisition of rural non-grid-connected TV sets would double, from 750 to 1500 sets per year, and half the new owners would acquire PV. These assumptions indicate a total demand for 8,750 sets at 20 Wp each, or a total of 175 KWp over the next five years. This result is a rough guess at best, but indicates that the market potential for PV modules

for operating home TV sets in Morocco over the next five years may be larger than the potential for PV in all other uses put together. Development of this potential will depend on:

(a) design of a PV module which is specifically designed to fit the TV sets and batteries commonly in use in rural Morocco, which contains all the necessary elements (including connecting cables, mounting rods, etc.) and which is of the minimum size required for powering the TV set (not a system designed to power TV, lighting and various home appliances together);

(b) proper advertisement of the systems; and

(c) encouraging competition among various dealers to keep dealer margins to a minimum.

The market potential of PV for other home appliances such as lighting, fans and air conditioners is probably a small fraction of the potential for PV-TV. For these other appliances, inexpensive and reliable alternatives do exist (e.g. the butane refrigerator and the Coleman-type pressurized kerosene lamp), and consumers are unlikely to invest as large sums for these appliances as they would pay to have an independently powered TV set.

7.2 TV Repeater Stations

The present situation: In the often mountainous topography of Morocco, coverage of the rural areas by the television network necessitates a considerable number of repeater stations. These stations, which are located at high spots, receive signals from the main TV stations and broadcast them to TV receiver sets in the surrounding areas. The output capacity of these repeater stations is usually 10W to 50W; the corresponding input capacity necessary to operate the stations is about 120W to 600W. The repeater stations work only during TV broadcasting hours (6 to 12p.m. on weekdays, and 2 to 12p.m. on weekends, or a total of 50 hours per week). At present there are 18 TV repeater stations in Morocco; 14 of these are connected to the grid, three are powered by diesel generators and one repeater station is powered by a PV system. The PV system was installed two or three years ago (using U.S. equipment), and is functioning to the complete satisfaction of the Television Directorate.

Cost of a PV system: A TV repeater station with a 600W input power requirement working 50 hours per week would consume 30 Kwh per week. At a power production of 4-watt hours/day per peak watt the necessary power could be generated by a 1-KWp PV array with battery capacity. It is assumed that for this public sector application, the 34% customs duty and 15% sales tax will be waived. Table 6.2 estimates that the present value of life-cycle cost of a 1 KWp PV system in Morocco will be about $30,800 at 1980 equipment costs, or about $19,000

at projected equipment costs in 1982.

Cost of the grid connection alternative: The cost of an 11.2 KV power line is about $9,000/km, plus a cost of about $2,000 for a 10KVA transformer (the smallest available size). At an electricity cost of $0.08/KWh, a repeater station with an input of 600W working 50 hours per week has an electricity consumption cost of $125/year; at a discount rate of 15%, a 20-year supply of energy has a present worth of $900. Thus the life-cycle cost of a 2 km grid extension is about $20,900. Comparing this with the PV costs above, it is seen that as of 1982 a 1 KW PV installation will be competitive with grid power whenever the connection distance is over 2 km; at 1980 prices, the break-even distance is about 3 km. This condition is satisfied at most repeater station sites, which are typically located on hilltops at a significant distance from the power system of the population served.

Cost of a diesel generator alternative: A 6.25 HP generator would be used in this application, the smallest size in wide use in Morocco. The present value of life-cycle costs for this motor are shown in Table 6.3 to be about $11,070. To this should be added attendant's wages of $100/month (over 20 years, a present value of $8640), since the comparable PV installation would be unattended. The present value of a 2-year cost for a diesel generator is thus about $19,700. Thus as of 1982 PV will be cost-competitive with diesel for TV repeater stations as well beside the higher reliability and fewer maintenance problems associated with PV.

The market for PV: The Television Directorate expects to install 40 to 50 additional TV repeater stations over the next five years. The technical department is interested in equipping all or most of these stations with PV power in view of the usually isolated location of the stations, the problems with diesel generators, and the positive experience with the pilot PV system. The maximum market potential for PV in TV repeater stations is therefore on the order of 40 KWp.

Television relay stations: Unlike TV repeater stations, which broadcast directly to receiver sets, TV relays are larger stations used to transmit signals from one major TV station to another. A relay station needs a power source of about 1 KVA for a 24hr/day operation; in Moroccan conditions this requires a 6 KWp PV array. At present there are 13 such TV relay stations in Morocco. According to the Television Directorate technical division, ten of these are grid-connected, two are diesel-powered and one is wind-powered. The Television Directorate plans to install 10 to 20 additional TV relay stations

over the next five years. Most of these, however, will be grid-connected. The TV Directorate sees the main applications of PV power in repeater stations rather than in the larger relay stations.

Radio stations: Unlike TV stations, the main radio stations cover the entire country. Thus the radio network does not require PV to power isolated stations.

7.3 Microwave Relay Stations

The present situation: Microwave stations are located on high points in the topography to provide line-of-sight transmission of phone, telex and telegraph messages among urban centers. Each microwave station needs 300W to 600W of power input, and operates 24 hours per day. Six of the existing microwave stations are not grid-connected and are powered by diesel generators. The Transmissions Division of the P.T.T. (State Ministry of Post, Telephone and Telegraph) experiences fuel supply and maintenance problems with these stations, as well as the problems associated with keeping operating personnel in isolated locations, and is interested in a PV alternative.

The economics of PV: For a 24-hour operation of a 600 W installation, the required array capacity should be about 3.6 KWp with battery storage. According to Table 6.2 the life-cycle cost of such an array would be about $111,000 in 1980, $68,000 in 1982, $55,000 in 1984 and $41,000 in 1986. The break-even distance with a grid connection ($9,000/km, plus transformer and electricity) is 7km in 1982, decending to 4 km in 1986; this is less than the distance of most microwave stations from the grid. As to diesel generators (assuming requirements for a 24 hour/day year-round operation), the total life-cycle cost (including maintenance) would be about $74,000. Thus as of 1982 PV will be competitive in this use with diesel generators or grid electricity.

The market for PV: The head of the PTT Transmissions Division has requested a price estimate (CIF Casablanca) for a PV installation capable of delivering 600 W for a 24 hour/day operation. The Transmission Division plans to install about 20 microwave stations during the next five years. Assuming that each station would require a 3.6 KWp PV array, and that only ten of these stations will be located in sites for which grid connection will cost more than the PV installation, there will be a maximum potential for about 36 KWp in this application.

7.4 Railroad Signals

Unguarded railway level crossings: The Moroccan rail system has about 560 unguarded level crossings. At present these are equipped with stop signals

only. The ONCF (Office National des Chemins de Fer du Maroc) wishes to equip all of these with flashing red lights to increase security. The signal lights used for this purpose are 6.5V, 25W lamps which flash 24 hours per day. One lamp is installed on each side of the tracks.

The market for PV: With a DC power production of 4 watt-hours/day per peak watt as a minimum, each crossing would require a 2x25x24/4=300 Wp module capacity. For the large majority of the existing crossings PV is the only practical alternative, since they are located in rural areas far from electrical lines and the cost of connecting them to the grid is higher than PV costs even at present prices (1980 break-even distance being about 1 km). Note that the opportunities for utilizing PV-powered signal lights exist mainly in the existing railway system rather than in the projected 961-km Marrakech-Laayoun line, which passes mostly through sparsely-inhabitated regions and will have relatively few level crossings.

The first step in introducing PV to this use would be to install PV-powered demonstration signals on one easily accessible intersection. Subject to ONCF approval of the method and to budget availability, perhaps 20 level crossings could be equipped with warning lights annually over the next five years, with a total module capacity of 30 KWp.

Guarded railway level crossings: The ONCF system also has about 20 guarded level crossings equipped with barriers. Each such crossing would need flashing lights as above, plus about 250W capacity for 5 hours per evening for lighting and other uses in the adjoining guard house. Thus the required module capacity would be about 600 Wp per installation. Photovoltaic systems are likely to be installed in guarded railway crossing later than in unguarded ones, and probably not during the coming five years.

Small railway stations: The ONCF system also has about 20 small railway stations in remote rural areas. Each such station requires an electrical capacity of about 10 KW, of which about 1 KW is needed permanently for signal lights and other uses, and the rest for lighting the station area and personnel quarters during the evening hours. Every such station could thus be powered by a PV installation of about 15 KWp. At present such stations are powered by diesel generators. The use of PV for rural railway stations is likely to occur considerably later than for level crossings, and most likely not during the next five years.

7.5 Marine Signals

The present situation: Marine signals in Morocco are of four types:

(a) Lighthouses: of which there are 40 to 50 along the Moroccan coast. These are powered by electricity (where available) or gas tanks, and have projectors of 36 W to 6000 W power.

(b) Radio signals: of which there exist two (400 W and 700 W output), both in the port of Casablanca, and both grid-connected.

(c) Jetty Lights (2-3 in each of the 20-30 ports of Morocco) and other port lighting, all connected to the electricity networks of the ports in question.

(d) Light buoys: About 20 of these are in permanent service to indicate ship channels into the major ports. About 100 more are in reserve to be used in emergencies. Each light buoy has a gas lamp with a two-year gas supply, and a standby battery-operated system with a power of 80 W and a capacity for one year of independent operation.

Potential for PV application: In the U.S. such marine signals have been perhaps the field most completely penetrated by PV, because of the difficulty of supplying conventional forms of energy. In Morocco, the promising applications for PV are:

(a) Light buoys: The Directorate of Secondary Ports plans to install up to about 100 permanent light buoys in the coming five years. Assuming 80W power requirement, 12 hour/day operation, and four peak-hours equivalent of insolation per day, the maximum requirement will be for 24 KWp of array capacity.

(b) Lighthouses: The Directorate of Secondary Ports intends to renew the existing chain of lighthouses, converting the gas-lit units to electricity where possible. Assuming that of the lighthouses renewed during the coming five years, twenty gas-powered units require an average output of 200 W each and can be provided with PV systems at less than the cost of a grid connection, there will be a demand for a total PV installation capacity of 12 KWp.

7.6 Airport Signals

The present situation: Beside the international airports, Morocco has about 20 small airports for domestic and unscheduled flights. These airports are often located in rural areas, far from the electricity networks of the towns which they serve. These airports are served by diesel generator sets. However, each airport has three radio beacons located 700, 1500 and 7000 m ahead of the landing strip. These beacons consume very little power, but function continuously. Due to the inconvenience of maintaining and periodically replacing electric ground cables over such distances, the Air Directorate would prefer to power these beacons by PV panels. In addition, every airport has a 24V interior telephone system; these systems are not serviced by the diesel

generators but by batteries, which must be taken periodically for recharging.

The market for PV: Assuming that every small airport has three beacons and a telephone system with an input capacity of 50W each, and that every peak watt generates a minimum of 4 watt hours per day, every small airport would need a module capacity of about 300 Wp. Assuming that one half of this potential would be realized during the coming five years, the total PV market for airport during this period would be about 3kWp.

Advance antennas: The airline signalling system also includes "advance antennas". These are VHF radio relays which are located away from airports on the major air routes and beam signals which help the planes to navigate. The advance antenna system of Morocco is fairly complete with about 12 stations, and the Air Directorate does not expect a significant use of PV power for this purpose in the foreseeable future.

7.7 Traffic Counters

Present situation: The CNAC (Centre National d'Auscultation des Chaussees--National Center for Highway Research) has about 100 traffic counters placed on different highways in Morocco. Each counter consumes up to 10W continuously. These traffic counters are activated by 12 V rechargable batteries of a special type, which provide up to one month of independent operation. Nevertheless, the CNAC has encountered a number of operational problems with those batteries and is interested in replacing them by PV power. The CNAC also has one dynamic scale which measures the axle load as well as the number of passing vehicles, and is interested in acquiring several more; each dynamic scale consumes about 20 W continuously.

The market for PV: If a pilot installation functions to the satisfaction of the CNAC, the 100 existing traffic counters might be equipped over the coming five years with solar panels. With a DC power production of 4 watt-hours/day per peak watt, a 10W counter would need a 60 Wp panel. Thus the maximum potential demand for this application may be on the order of 6KWp.

7.8 Rural Radio Telephones

The present situation: Radio telephones are necessary to assure telephone communications to isolated villages. These are small installations consuming up to 50 W of total power and normally operating 8 hours a day except for emergencies. The Transmissions Division of the P.T.T. has installed one PV-powered radio telephone in a remote mountain location, with satisfactory results.

The market for PV: The Transmissions Division plans to install over the next five years some 70 to 80 small radio telephone stations of up to 50 W capacity. Assuming that at least 40 of these stations will be located in villages which do not have grid power or dependable diesel-generated power, and that for 8 hours per day operation each station would need 100 Wp panel capacity, the total market in this application would be on the order of 4 KWp.

7.9 Refrigerators for Rural Clinics

The present situation: The Moroccan public health system has about 700 rural dispensaries, of which about 200 are located in villages which do not have electricity. The number of dispensaries increases by about 5% annually, but rural electrification is likewise increasing so that the total number of dispensaries without electricity is likely to remain constant during the five coming years. Each dispensary needs a refrigerator to store medicines and vaccines. Where electricity is not available, butane refrigerators are used. The UNICEF is committed to extending the "cold chain" (facilities for medicine refrigeration) to all urban dispensaries by the end of 1981 and to all rural dispensaries by the end of 1982.

Comparison of PV and butane refrigerators: The butane absorption refrigerator is a simple machine which has no moving parts. It is activated by a small gas flame (much like a stove pilot light) which warms a coiled tube, evaporating the refrigeration fluid it contains; the gas produced flows into another coil within the refrigerator where it is absorbed, removing heat from the refrigerator in the process. The butane refrigerator has an expected useful life of 10-20 years--about twice as long as electric refrigerators which may be powered by PV panels. In this application a PV system cannot be justified on the basis of superior reliability, so that its only advantage lies in avoiding the inconvenience involved in assuring a regular supply of butane containers. Thus in the situation of Morocco, PV-powered medical refrigerators would be advantageous mostly for clinics in isolated mountain or desert villages, where the transport and cost of butane containers poses real problems. Roughly 50 to 60 of the rural clinics in Morocco fall into this category.

The economics of PV refrigerators: A 140 l butane refrigerator costs about $400 installed in Morocco. A butane gas container costs $6.50 in the market place, or (including transport to the clinics) a maximum of $8.00. A butane refrigerator consumes about one container per month, so that annual fuel costs are about $100. Maintenance costs are minimal. At a 15% discount rate, the present value of a 20-year supply of butane is $720. Adding the

purchase price, the life-cycle cost of a butane refrigerator is about $1120. In comparison, the current cost of a PV-powered medical refrigerator has been quoted at $2500 (FOB in the U.S.). To this must be added shipping, handling, and customs costs as well as replacement of the electric motor/compressor unit every 5 to 10 years. Thus unit costs must come down to about $1000 before PV refrigerators will be cost-competitive with butane refrigerators. In the intervening period, PV refrigerators will be useful mainly in isolated locations where difficulties in butane supply make the butane refrigerator impractical. The necessary battery storage capacity is minimal (sufficient for about 3 days of operation), since the problems with medicine conservation occur mainly in the summer.

The market for PV: Ministry of Health officers are quite interested in the installation of PV refrigerators, but budget limitations make development of this market dependent on foreign donor activity. Given budget, PV refrigerators could be usefully installed over the next five years in 40 to 50 locations. The specifically designed PV medical refrigerator which consumes about 20 amp-h/day at 12 VDC (240 Wh/day) requires a module capacity of 60 Wp. Thus the total market potential is about 3kWp. The USAID/Rabat is currently considering the acquisition of five PV-powered refrigerators, which should furnish a useful pilot experience concerning this application.

8.0 MARKET ASSESSMENT/CONCLUSIONS

From the analyses of potential PV applications in Morocco in Chapters 6 and 7, it is seen that practically all market opportunities over the next five years will be in the areas of telecommunications and signalling. Agriculture, the principal focus of the market study, was found to have very little PV market potential in the near term, and other rural sector service applications present only slightly better potential. Nevertheless, the near term market opportunities seem to represent sufficiently promising potential to warrant a close investigation by U.S. PV manufacturers of the Moroccan situation.

The maximum size of the potential market for PV in Morocco over the next five years is estimated to be as follows:

Table 8.1 - Morocco PV Market Potential (1981-1986)

(1)	Rural TV receivers	8750 units @ 20 Wp	175 kWp
(2)	TV repeater stations	40 units @ 1 kWp	40 kWp
(3)	Microwave stations	10 units @ 3.6 kWp	36 kWp
(4)	Railroad stations	100 units @ 300 Wp	30 kWp
(5)	Marine Signals:		
	light buoys	100 units @ 240 Wp	24 kWp
	lighthouses	20 units @ 600 Wp	12 kWp
(6)	Traffic counters	100 units @ 60 Wp	6 kWp
(7)	Airport signals	10 units @ 300 Wp	3 kWp
(8)	Rural radio telephones	40 units @ 100 Wp	4 kWp
(9)	Refrigerators for rural clinics	50 units @ 200 Wp	10 kWp
	Total Maximum Demand for PV		340 kWp

The market size estimates are based on the analyses performed in Chapter 6 and 7, and represent first approximations. They should, however, be sufficiently accurate to indicate the order of magnitude of the potential for different PV applications. At an average customer cost for complete installed systems from $18/Wp to $30/Wp, the total potential market value of 340 KWp is estimated in the range of $6.1 million to $10.2 million over the period.

In all uses except PV-TV the clients are public agencies. The above estimates of this institutional market are an approximation based on the declared objectives and expected budgets of agencies and services interested in purchasing PV systems as indicated by the directors of these organizations. A more definitive market estimate may be possible in a few months upon the publication of the

1981-1985 five-year plan. Realization of the institutional potental market will further depend on:

- the degree of success of the government agencies concerned in obtaining and executing the planned budgets; and
- the cost-competitiveness of PV systems in each individual case, which in turn will depend to a considerable extent on the markup of the distributors of PV systems and on the customs duties levied on PV.

The growth rate of the potential PV market over the period 1981-1985 is too uncertain to permit a further division of the five-year market potential into annual sales potential or targets. For example, in some applications judged to have significant potential for PV, such as TV receivers and marine signals, the market will require early stimulation, advertising, and testing with sales accelerating in several years. It can only be estimated that certain applications in which pilot experience already exists in Morocco (notably radio-telephone, microwave and TV repeater stations) may soon be ready for more substantial orders, while in other uses (e.g., railroad, airline and marine signals) a pilot demonstration must be the first step.

In the study, rural TV receivers are shown to have a potential market over the next five years larger than all other applications combined. This potential is enhanced by the existence of dealer credit systems which can be used for financing the purchase of PV power, by the inconvenience of the alternative power source (battery recharging), by the cost-competitiveness of PV in this use, and by the prestige it is likely to confer on the user. An important consideration for the development of PV markets in Morocco and elsewhere is that widespread use of "PV-TV" could also be the ideal means to familiarize the rural sector with PV power and to create the distribution and maintenance network which will facilitate the spread of other PV uses as they become cost-competitive. However, at present this is only a potential. Exploitation of the PV-TV market will depend on:

- manufacturing dependable PV packages which readily fit the types of TV sets and batteries in common use in Morocco (or elsewhere);
- proper advertising; and
- encouragement of competition among dealers to maintain a reasonable consumer price.

In Moroccan agriculture, the potential for PV markets over the next five years years is considered insignificant, but improving in the medium and longer terms. Like many developing nations, Morocco clearly has a need for reliable remote power systems for numerous agricultural applications. But Moroccan public sector agricultural institutions which might be interested in PV power because of its greater reliability in comparison with diesel motors, even where it is not competitive

in strictly cost terms, are operating under severe budget limitations. Barring donor assistance, they are unlikely to find the budget for the high initial capital cost PV installations. Two, private sector uses of power in Moroccan agriculture (except for mobile power uses, i.e., tractors and combines) are limited almost entirely to water pumping for irrigation. Because of the deep water table in Morocco and the fact that irrigation pumping is commonly done from a depth of 20 to 40 meters, PV will not be cost-competitive in most Moroccan irrigation in the next five years. An exception may be low head, small-scale irrigation pumping uses.

For the following agriculture and rural service applications the use of PV was rejected on grounds of cost. It should be noted that cost analyses used assumptions favorable to PV by assuming a waiver of customs duties and sales taxes for public sector purchases and by assuming a low 30% margin for PV distributors. These comparisons are also based on PV's projected lower cost in 1986.

> Irrigation: At projected 1986 prices, the life cycle cost of the smallest (6.25 HP) diesel motor used to deliver 8.3 l/s from a depth of 15m will be half the life cycle cost of the PV alternative ($12,000 vs. $23,600). The 15m groundwater depth is minimal for Morocco; at larger depths PV economics are worse. Diesel also has the advantage of financing flexibility (lower front-end cost), operational flexibility (diesel can be operated continuously if necessary while PV is limited to about five peak hours-equivalent per day), and risk reduction (spare parts and repair facilities for diesel are widely available).

> Village water supply: A 20KWp PV system required for supplying water to 2000 villagers from a depth of 50m (the average Morocco village water supply project) will have a life-cycle cost in 1986 three times that of its 12.5 HP diesel alternative ($131,000 vs. $40,000); front-end costs are $124,000 vs. $2200. Smaller potable water projects plan to employ used windmill pumps, which are plentiful in Morocco, and with which PV is not now competitive.

> Grain Mills: The ordinary mill will require a 10 KWp PV system, which alone will cost $114,600 in 1986, compared with its alternative-- a 12.5 HP diesel motor costing $2200. Due to the need for storage batteries and to the long working hours (which allow efficient use of the diesel equipment), PV is less competitive with diesel in milling than in pumping.

> Highway lighting: The break-even distance at which a PV system is cheaper than a grid connection is 10 km in 1982, and 6 km in 1986. Most or all intersections which will be equipped with lights during the period are located within this distance from the grid.

The possibility for using PV for livestock watering, veterinary extension posts, cold storage for fisheries, and educational television was investigated but rejected, primarily because the entire market for any power source in these applications in non-grid connected locations over the next five years will

be insignificant. A modest potential for PV use was identified in some non-agricultural rural services, such as refrigerators for rural clinics and rural radio-telephones.

The 1986 time horizon is significant because by that date, PV is projected to be cost-competitive with grid electricity as a daytime energy saver for residential and industrial applications. When this situation is attained, vast markets will open for PV in the areas which already have electricity, and the assessment of applications in non-grid-connected locations is likely to lose its motivation. Accordingly, if the date of PV cost-competitiveness with the grid is delayed, its cost-competitiveness in non-grid locations will be postponed.

Tables 1.3 and 1.4 show the crucial economic consideration: by 1986 PV power is projected to cost $1.60/Wp as a daytime grid electricity saver, as against $3.87/Wp to $6.55/Wp in stand-alone applications (depending on whether or not battery storage is required). This cost difference more than offsets the higher cost of diesel power as compared to grid power. Consequently, PV will be able to supplement grid energy considerably sooner than it can replace non-grid energy. The field findings and the basic economic parameters offer little support to the thesis that because of the absence of grid electricity in larger areas of Morocco, these areas offer signficant markets for PV power.

In sum, the growth path for PV power in Morocco will likely be similar to its historic growth path in the U.S. Until PV is able to supplement grid power as a daytime electricity saver, the market for PV power in Morocco will be in telecommunications, signalling, battery charging applications, and small motors of up to 2KW (e.g., for irrigation from very shallow depths, or potable water for small communities), where a diesel motor works at distinct inefficiencies. It will probably not be in applications requiring motors of more than about 1-2KW. The upper power limit for PV in stand-alone applications up to 1986 is in this load range because the smallest diesel motor in use in Morocco is about 6HP or 3 to 5KW, and becomes significantly underutilized at smaller outputs.

Lastly, the important advantage of PV over diesel power is the convenience and relatively maintenance-free operation of PV systems. This advantage could swing the balance in favor of PV even where its cost is higher than that of diesel power. This advantage applies mostly to the public sector; in the developing countries, private-sector operators manage to keep

equipment operating, especially as their livelihood depends on it. But in the public sector, operating experience is not nearly as successful. Thus there may be a market for PV in the rural public services (e.g., rural water supply) of the sparesely-populated countries which can afford or are committed to cost-transcending considerations to meet specific needs. Motor applications of more than about 1-2 KW load, however, seem to be excluded in poorer developing countries by cost considerations.

APPENDIX A

LIST OF CONTACTS

LIST OF CONTACTS

Public Sector

Ministry of Energy and Mines--Center for Development of Renewable Energies
B.P. 38, Marrakech -- Tel. (04) 331-04
Abdelhaq FAKIHANI--Project Director
Mahamed M'ZABI--Head of General Secretariat

Ministry of Energy and Mines--Electrical Division
9, Zankat Zenata Aviation, Rabat--Tel. 614-60
Laidi AFSAHI--Chief of Electrical Division

Ministry of Energy and Mines--Energy Directorate
14 Rue About Faris el Marini, Rabat--Tel. 342-57
Houmad HOUDALGUI-Chief, Division of Energy Resources Development

Ministry of Agriculture and Agrarian Reform--B.P. 1069, Rabat
Direction de l'Equipment Rural (rural works directorate)
Mohamed LAHRECH--Chief, Division de l'Amenagement Rural
(rural infrastructure division)--Tel. 51-574
Lahcen ZAGHLOUL--chief, service de la Petite et Moyenne Hydraulique
(small and medium irrigation projects)--Tel. 51741
Mohammed ZAHRI--Chief, Communal works service/administrative buildings
service--Tel. 50702 x387/x 398
Jan CZAPLINSKI--Technical Advisor
Haddou DERROUICH--Chief, Service de l'Equipement Rural, Khemisset
Abdallah GUENNONE--Chief, Bureau de l'Amenagement Rural, Khemisset
Mohammed BENZIANE--Chief, Khemisset Subdivision

Ministry of Agriculture and Agrarian Reform--B.P. 1069, Rabat
H.E. Abbas MARSILE--Livestock Director--Tel. 650-77
Taleb BEN SOUDA--Assistant livestock director
Abdel Wahid GHARBAWI--Chief, animal feed division

Ministry of Agriculture and Agrarian Reform
Livestock Service, Place 16 November, Marrakech--Tel. 31904/03
Dr. SAMI--Chief, livestock service
Farid NACIRI--Chief, animal production office
Dr. PLAIC--Chief, animal health office

Ministry of Agriculture and Agrarian Reform
Rural Works Service, Marrakech
M.AIT LAGHOURARI--Deputy Chief of rural works service
Mohammed MOUMEN--Chief, Amizmiz agency

State Ministry of Information
RTM (Radiodiffusion et Television Morocaine)
1, Rue El Brihi, Rabat--Tel. 6503/62740
Saddek MA'ANINOU--Director of Television--Tel. 620-10
Jamaleddin TANANE--Technical Director
Ahmed EL HAOUARI--Chief, Television Broadcasting service
Mohamed AFKIR--Chief, Television relay division

Ministry of Transport--Roads Directorate--Technical Division
Mohammed Ali HASNAOUI--Chief, Road location service--Tel. 640-40

Ministry of Transport--CNAC (Centre National d'Auscultation des Chaussees--
National Road Research Center), B.P. 1323, Rabat
Dr. Abdelaziz DAHBI--Chief, road structure planning department

Ministry of Transport--Air Directorate
Mohamed EL MOUMMY--Chief, telecommunications section--Tel 73065

Ministry of Equipment and National Promotion--Administrative Quarter, Rabat
Service of Secondary Ports
M. HACHIMI--Chief, marine signals office--Tel. 620-08/61034 x 229

State Ministry of Post and Telecommunications--Ave. Moulay Hassan, Rabat
M. AHIZOUNE--Chief, transmissions division--Tel. 61935

ONP (Office National de la Peche)
13, Bd Chevalier Bayard, Casablanca--Tel. 24-05-51/24-07-94
Abdelali LAHLOU--Director of General Studies

ODI (Office pour le Developpement Industriel)
10 Rue Gandi, B.P. 211, Rabat
Abdelfattah CHERAIBI--Chief of rolling stock, electromechanical department--
Tel. 38314

ONCF (Office National des Chemins de Fer du Maroc--Moroccan National Railway
Authority)
Zankat Abderrahman AL CHAFIKI (near Agdal railway station) Rabat--Tel. 74747
Mohamed AL-AICHAOUI--Chief, rail service
Moktar EL HOUSNI--Chief, electric signalling office
Mohamed SERRAJ--Chief, telephone and lighting office

ONE (Office National de l'Electricite)
65 Rue Aspirant Lafuente, Casablanca--Tel. (9) 22-41-65/26-65-53/22-33-30

Ministry of Public Health (Ministere de Sante Publique)
IBN TOUFAIL Hospital, Marrakech--Tel. 306-11/325-09
Mohamed ZAROUF--chief doctor of Marrakech medical province

Banque due Maroc, Marrakech
Mahdi TAZI, Director--Tel. 239-70/220-37/256-15

Banque Marocaine du Commerce Exterieure--241 Bd. Mohammed V, Casablanca
Tel. 30-91-44
Mohamed LEBBADI, Deputy Director, Direction du developpement

SIMEF (Societe des Industries Mecaniques et Electriques de Fes)
Km 10, route d'Ain Chkef, B.P. 41, Fes--Tel. 416-43/44
M. BEL AHSEN--general manager
Rami LAHSEN--Financial director

Private Sector

UCIM (Union Commerciale et Industrielle du Maroc)
    137, Bd. de la Resistance, Casablanca--Tel. 30-00-19/39-92-94
Jacques CHARRIERAS--Chief of Technical Department
Houcine BERRADA--Administrator-delegate

Ets. F. HAMES--23, Rue de Champigny, Casablanca--Tel. 30-26-79/30-62-79
Ferdinand HAMES--General Manager

SOMAI, S.A. (Societe des Materiels Agricoles et Industriels)
    Bd. de la Resistance (corner Eugene-Barathon), Casablanca--Tel. 24-13-25/24-13-06
Rachid BENBRAHIM--Administrator-delegate

AUTO-HALL, S.A--44 Ave. Lalla Yacout, Casablanca--Tel. 22-41-74
Jean MAPOU--Director of Marrakech Agency--Tel. 307-10/307-11

Establissements Dolbeau & Fils--81 Rue Karatchi, Casablanca--Tel. 30-41-82
A. IDRISSI, Chief, Electronics department

Ets. THONIEL, Marrakech
M. EULOGE--Technical director

UNIVERSEL-EQUIPEMENT, S.A.
190, Ave. Moham V, Marrakech--Tel. 333-31
M. MACIA, Director

U.S. Representatives

U.S. Embassy, Rabat--Tel. 622-65 (B.P. 120)

M. REDIKER--Economic Officer
Russell Frost GRAHAM--Second Secretary
Forrest GEERKEN--Agricultural Attache
James L. BULLOCK--Director (interim), American Cultural Center
    10 Place Bel Air, Casablanca--Tel. (02) 214-60

USAID, Rabat
    137, Ave. Allal Ben Abdallah, Rabat--Tel. 62265 (B.P. 120)
Harold FLEMING--Mission Director
Mark WARD--Program officer
Andres ACEDO--Procurement officer
Marion FORD--Agricultural officer
Mohamed HANAFI--Agricultural specialist
George CORVALDI--Human resources development officer
Thomas F. EIGHMY--Economist
Jerry BOWERS--Population/health officer
M. BENARBDESSELAM--Education analyst
Ursula NADOLNY--Public health/nutrition specialist

U.S. Consulate, Casablanca--8 Bou. Moulay Youssef
Donald MEYERS, Commercial Attache

<u>Other</u>

<u>UNICEF</u> North African Area Office
Sub-office: Rabat, Morocco
Mr. Leo DEVOS, Deputy Representative

APPENDIX B

PROJECTED COSTS OF PV SYSTEMS

C-2

TABLE B.1: 1980 COST OF A 20Kwp REMOTE STAND-ALONE P/V SYSTEM (IN JULY 1980 DOLLARS)

	SYSTEM PRICE ELEMENT	INITIAL PRICE $\$W_p$ (1980\$)				ENERGY PRICE ELEMENTS $\$W_p$ (1980\$)		LEVELIZED ENERGY PRICE, ¢/kWh (1980\$)		
		FOB MANUFACTURER	MARKETING & DISTRIBUTION	INSTALLATION	SUBTOTAL	INITIAL INSTALLED SYSTEM PRICE	LIFE CYCLE OPERATION & MAINTENANCE	2350 kWh/kW_p	1770 kWh/kw_p	1400 kWh/kw_p
ARRAY	• COLLECTOR	10.60	INCL	0.81	11.41	13.60	0.13	109.4	145.2	183.6
	• STRUCTURES & FOUNDATIONS	0.60	0.12	0.40	1.12					
	• SITE & PREPARATION	-	-	0.56	0.56					
	• FIELD WIRING	-	-	0.44	0.44					
	• LIGHTNING PROTECTION	-	-	0.07	0.07					
POWER PROCESSOR	• POWER CONDITIONER	0.49	INCL	0.05	0.54	0.86	0.13	7.7	10.2	12.9
	• ELECTRICAL SWITCHGEAR & WIRING	0.11	0.06	0.05	0.22					
	• CONTROL BUILDING	-	-	0.10	0.10					
STORAGE	• BATTERY	2.60	0.52	0.08	3.20	3.68	2.80	48.0	63.7	80.6
	• CHARGER	0.10	0.03	0.04	0.17					
	• BATTERY BUILDING	-	-	0.31	0.31					
INDIRECTS	• DESIGN & PROJECT MANAGEMENT FEE				2.71	2.71		21.6	28.7	36.3
	• SALES FEE				0					
	• INTEREST DURING CONSTRUCTION									
TOTAL, COMPLETE SYSTEM		14.50	0.73	2.91		20.85	3.06	186.7	247.8	313.4
TOTAL, w/o BATTERY STORAGE		11.80	0.18	2.48		17.17	0.26	-	-	-

Assumptions

- 8% Collector Area Efficiency
- Marketing & Distribution: Collector -% Structure 20%, Electrical 50%, Storage & Equipment, 20%.
- Fees: Design and Project Management, 15% Sales: 0%.
- Lifetimes: System 20 years, Economic 20 years.
- Operation & Maintenance: $\$16/kW_p$/yr.
- Utilization Factor (U): 0.64
- Fixed Charge Rate: 0.12
- Discount Rate: After taxes (k) 8%
- Battery: $170/kwh Initial FOB Price: 10 year Life; 3 days Storage ($15kwh/kw_p$)
- Inflation Rate(g) 6%
- Capital Recovery Factor: 0.10

Source: JPL, "1980 Photovoltaic Systems Development Program Summary Document" (Draft)

TABLE B.2: 1982 COST PROJECTIONS OF A 20 Kwp REMOTE STAND-ALONE P/V SYSTEM
(IN JULY 1980 DOLLARS)

	SYSTEM PRICE ELEMENT	INITIAL PRICE $W_p (1980$)				ENERGY PRICE ELEMENTS $W_p (1980$)		LEVELIZED ENERGY PRICE, ¢/kWh (1980$)		
		FOB MANUFACTURER	MARKETING & DISTRIBUTION	INSTALLATION	SUBTOTAL	INITIAL INSTALLED SYSTEM PRICE	LIFE CYCLE OPERATION & MAINTENANCE	2350 kWh/kW$_p$	1770 kWh/kW$_p$	1400 kWh/kW$_p$
ARRAY	• COLLECTOR	2.80	0.84	0.40	4.04	5.84	0.13	47.5	63.1	79.7
	• STRUCTURES & FOUNDATIONS	0.50	0.10	0.30	0.90					
	• SITE & PRE-PARATION	-	-	0.50	0.50					
	• FIELD WIRING	-	-	0.35	0.35					
	• LIGHTNING PROTECTION	-	-	0.50	0.05					
POWER PROCESSOR	• POWER CONDITIONER	0.22	0.11	0.05	0.38	0.70	0.13	6.4	8.6	10.7
	• ELECTRICAL SWITCHGEAR & WIRING	0.11	0.06	0.05	0.22					
	• CONTROL BUILDING	-	-	0.10	0.10					
STORAGE	• BATTERY	2.60	0.52	0.08	3.20	3.68	2.80	48.0	63.7	80.6
	• CHARGER	0.10	0.03	0.04	0.17					
	• BATTERY BUILDING	-	-	0.31	0.31					
INDIRECTS	• DESIGN & PROJECT MAN-AGEMENT FEE	X	X	X	1.51	1.51	X	12.0	15.9	20.1
	• SALES FEE				0					
	• INTEREST DUR-ING CONSTRUCTION				-					
TOTAL, COMPLETE SYSTEM		6.33	1.66	2.23	X	11.73	3.06	113.9	151.3	191.1
TOTAL, w/o BATTERY STORAGE		3.63	1.11	1.80		8.05	0.26	-	-	-

Assumptions

- 10% Collector Area Efficiency
- Marketing & Distribution: Collector 30% Structure 20%, Power Conditioning & Electrical 50%, Storage & Equipment 20%
- Fees: Design and Project Management 15% Sales, 10%.
- Lifetimes: System 20 years, Economic 20 yrs.
- Operation & Maintenance: $16/kW$_p$/yrs.
- Utilization Factor (U): 0.64
- Fixed Charge Rate: 0.12
- Discount Rate: After taxes (k) 8%
- Battery Sotrage: 3 days (15 kWh/kW$_p$) $170 kwh Initial Price, 10 year Life
- Inflation Rate(g): 6%
- Capital Recovery Factor: 0.10

Source: JPL, "1980 Photovoltaic Systems Development Program Summary Document" (Draft)

TABLE B.3: 1986 COST PROJECTIONS OF A 100 Kwp REMOTE STAND-ALONE P/V SYSTEM
(IN JULY 1980 DOLLARS)

	SYSTEM PRICE ELEMENT	INITIAL PRICE $W_p (1980$)				ENERGY PRICE ELEMENTS $W_p (1980$)		LEVELIZED ENERGY PRICE, ¢/kWh (1980$)		
		FOB MANUFACTURER	MARKETING & DISTRIBUTION	INSTALLATION	SUBTOTAL	INITIAL INSTALLED SYSTEM PRICE	LIFE CYCLE OPERATION & MAINTENANCE	2350 kWh/kW$_p$	1770 kWh/kw$_p$	1400 kWh/kw$_p$
ARRAY	• COLLECTOR	0.70	0.21	0.20	1.11	2.49	0.13	19.0	25.2	31.9
	• STRUCTURES & FOUNDATIONS	0.40	0.08	0.20	0.68					
	• SITE & PREPARATION	-	-	0.40	0.40					
	• FIELD WIRING	-	-	0.25	0.25					
	• LIGHTNING PROTECTION	-	-	0.05	0.05					
POWER PROCESSOR	• POWER CONDITIONER	0.11	0.06	0.05	0.22	0.54	0.13	4.7	6.2	7.9
	• ELECTRICAL SWITCHGEAR & WIRING	0.11	0.06	0.05	0.22					
	• CONTROL BUILDING	-	-	0.10	0.10					
STORAGE	• BATTERY	1.83	0.37	0.08	2.28	2.68	2.04	32.0	42.5	53.7
	• CHARGER	0.10	0.03	0.04	0.17					
	• BATTERY BUILDING	-	-	0.23	0.23					
INDIRECTS	• DESIGN & PROJECT MANAGEMENT FEE				0.84	0.84		6.1	8.1	10.2
	• SALES FEE				0					
	• INTEREST DURING CONSTRUCTION									
TOTAL, COMPLETE SYSTEM		3.25	0.81	1.65		6.55	2.30	61.8	82.0	105.7
TOTAL, w/o BATTERY STORAGE		1.32	0.41	1.30		3.87	0.26	-	-	-

Assumptions

- 10% Collector Area Efficiency
- Marketing & Distribution: Collector 30% Structure 20%, Power Conditioning & Electrical 50%, Storage & Equipment 20%
- Fees: Design and Project Management 15% Sales, 0%
- Lifetimes: System 20 years, Economic 20 yrs.
- Operation & Maintenance: $16/kW$_p$/year
- Utilization Ractor (U): 0.70
- Fixed Charge Rate: 0.12
- Discount Rate: After Taxes (k) 8%
- Battery Storage: 3 days (15 kWh/kw$_p$), $120/kWh Initial Price, 10 years
- Inflation Rate(g): 6%
- Capital Recovery Factor: 0.10

Source: JPL, "1980 Photovoltaic Systems Development Program Summary Document" (Draft)

TABLE B.4: 1986 COST PROJECTIONS OF A 10Kwp RESIDENTIAL P/V SYSTEM
(IN JULY 1980 DOLLARS)

	SYSTEM PRICE ELEMENT	INITIAL PRICE $\$W_p$ (1980$)				ENERGY PRICE ELEMENTS $\$W_p$ (1980$)		LEVELIZED ENERGY PRICE, ¢/kWh (1980$)		
		FOB MANUFACTURER	MARKETING & DISTRIBUTION	INSTALLATION	SUBTOTAL	INITIAL INSTALLED SYSTEM PRICE	LIFE CYCLE OPERATION & MAINTENANCE	2350 kWh/kW$_p$	1770 kWh/kW$_p$	1400 kWh/kW$_p$
ARRAY	• COLLECTOR	0.70	0.21	0.17	1.08	1.12	0.22	3.3	4.4	5.5
	• STRUCTURES & FOUNDATIONS	-	-	-	-					
	• SITE & PRE-PARATION	-	-	-	-					
	• FIELD WIRING	-	-	0.04	0.04					
	• LIGHTNING PROTECTION	-	-	-	-					
POWER PROCESSOR	• POWER CONDITIONER	0.20	0.10	0.04	0.34	0.34	0.22	1.4	1.9	2.3
	• ELECTRICAL SWITCHGEAR & WIRING	-	-	-	INCL IN POWER COND.					
	• CONTROL BUILDING	-	-	-	-					
STORAGE	• BATTERY	-	-	-	-	-	-	-	-	-
	• CHARGER	-	-	-	-					
	• BATTERY BUILDING	-	-	-	-					
INDIRECTS	• DESIGN & PROJECT MAN-AGEMENT FEE	X	X	X	0.07	0.14	X	0.4	0.5	0.7
	• SALES FEE				0.07					
	• INTEREST DUR-ING CONSTRUCTION				-					
	TOTAL	0.90	0.31	0.25	X	1.60	0.44	5.1	6.8	8.5

Assumptions

- 10% Collector Area Efficiency
- Marketing & Distribution: Collector 30% Structure -%, Power Conditioning & Electrical 50%, Storage & Equipment -%
- Fees: Design and Project Management 5% Sales 5%
- Lifetimes: System 30 years, Economic 30 yrs.
- Operation & Maintenance: $16/Kw$_p$/year
- Utilization Factor (U): 0.63
- Fixed Charge Rate: 0.08
- Discount Rate: Before Taxes 10%, After Taxes (k) 6.5%
- Solar Availability (kwh/kw$_p$/yr): Phoenix 2350, Miami 1770, Boston 1400
- Inflation Rate(g): 6%
- Capital Recovery Factor: 0.077
- Factor to Convert From Levelized Normal To Real Energy Price(F): 2.10
- Tract House

Source: JPL, "1980 Photovoltaic Systems Development Program Summary Document" (Draft)

APPENDIX C

KEY ECONOMIC INDICATORS, 1976-1980

ORIGINAL PAGE IS
OF POOR QUALITY

MOROCCO: KEY ECONOMIC INDICATORS, 1976-1980

The figures below are as of the end of the periods indicated. They are continuously updated and are subject to revision if new and/or more reliable information justifies it.

p = provisional   e = estimate   r = revised

		1976	1977	1978	1979	1980
GENERAL						
Area : - total	'000 km2	660	660	660	711	711
- arable	'000 km2	77	78	78	78	78
- forest	'000 km2	51	51	51	51	51
Population :- total	'000s	17,826	18,359	18,906	19,470	20,050*
- rural	%	61	60	59	58	57
- under 20 years old	%	56	56	56	56	56
- active	%	25	25	25	25	25
Life expectancy at birth	years		55	55		
Infant death rate	‰		149	149		
Child death rate(aged 1-4)	‰		17	17		
Adult literacy rate	%		28	28		
Doctors : - private		616	669	762	883	
- public		838	908	978	1,091	
Hospital beds		23,146	23,669	23,958	24,452	
Students : - primary	'000s	1,668	1,794	1,925	2,052	
- secondary	'000s	525	582	651	727	
- university	'000s	45	53	62	74	
- specialized institutions	'000s	4.2	4.7	6.3	6.9	
Telephones	'000s		194	212	216	
Television sets	'000s	522	597	671	738	
Passenger cars	'000s	347	374	395	413	
Road network	km	51,456	55,240	55,840	56,203	
. of which : paved	km	23,465	24,670	25,020	25,131	
Tourist entries	'000s	1,218	1,502	1,546	1,549	1,517 (p)
Hotel beds (classified)	'000s	45,537	47,427	51,137	53,642	
Ressources and uses						
GNP, GOODS & SERVICES, SAVINGS						
Gross national product	DH mn	43,056	48,213	54,166	59,925	69,000 (e)
GNP per capita	DH	2,415	2,626	2,891	3,078 (e)	3,440 (e)
Consumption : - private	DH mn	27,658	31,807	35,241	38,941	
- public	DH mn	9,211	10,249	11,168	13,176	
Gross fixed capital formation	DH mn	11,778	15,349	13,400	13,055	14,100 (e)
of which :- equipment	DH mn	4,844	6,474	4,749	4,142	
- building	DH mn	2,912	3,885	4,736	4,546	
- public works	DH mn	3,498	4,417	3,282	3,689	
Gross national expenditure	DH mn	48,704	56,145	60,506	65,655 (p)	
Gross domestic savings	DH mn	4,447	4,764	6,451	6,256 (p)	
Gross national savings	DH mn	6,187	6,157	8,252	7,849 (p)	
GROSS DOMESTIC PRODUCT						
GDP at current prices	DH mn	41,012 (r)	47,041 (r)	52,755 (r)	58,292 (p)	67,500 (e)
GDP volume growth	%	+ 12.8 (r)	+ 6.5 (r)	+ 3.7 (r)	+ 3.1 (p)	+ 6 (e)
GDP breakdown and volume growth by sector(in parenthesis) :						
- agriculture	%	19.2 (+ 11.7)	16.7 (- 13.2)	19.1 (+ 19.1)	18.7(+ 0.8)	(+ 10 %)
- mining	%	5.6 (+ 5.3)	5.3 (+ 15.8)	4.8 (+ 6.5)	4.9(+ 5.3)	
- energy	%	2.5 (+ 6.9)	2.5 (+ 8.6)	2.7 (+ 5.1)	3.5(+30.8)	(+ 4 %)
- manufacturing	%	16.5 (+ 7.0)	16.4 (+ 7.2)	16.8 (+ 5.6)	16.6(+ 1.2)	
- building and public works	%	8.0 (+ 20.8)	8.9 (+ 15.0)	7.7 (- 12.9)	7.1(- 9.9)	
- transport	%	4.3 (+ 9.8)	4.6 (+ 13.0)	4.7 (+ 10.0)	4.5(+ 2.8)	
- services	%	13.4 (+ 12.5)	13.5 (+ 7.1)	13.5 (+ 2.2)	13.5(+ 1.1)	(+ 5 %)
- commerce	%	19.7 (+ 11.1)	20.3 (+ 8.5)	19.1 (- 3.7)	18.7(+ 1.4)	
- government	%	10.9 (+ 20.7)	11.8 (+ 13.8)	11.6 (+ 9.7)	12.5(+11.0)	

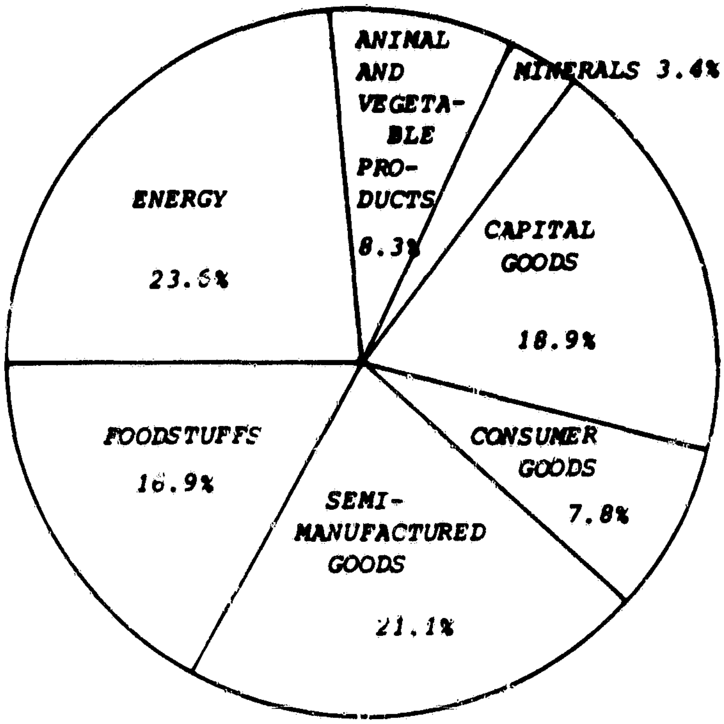
*mid-year estimates, including about 112,000 foreign residents

SOURCE: Banque Marocaine du Commerce Exterieure, Direction du Developpement, 241 Boulevard Mohammed V, Casablanca, Morocco, March, 1981.

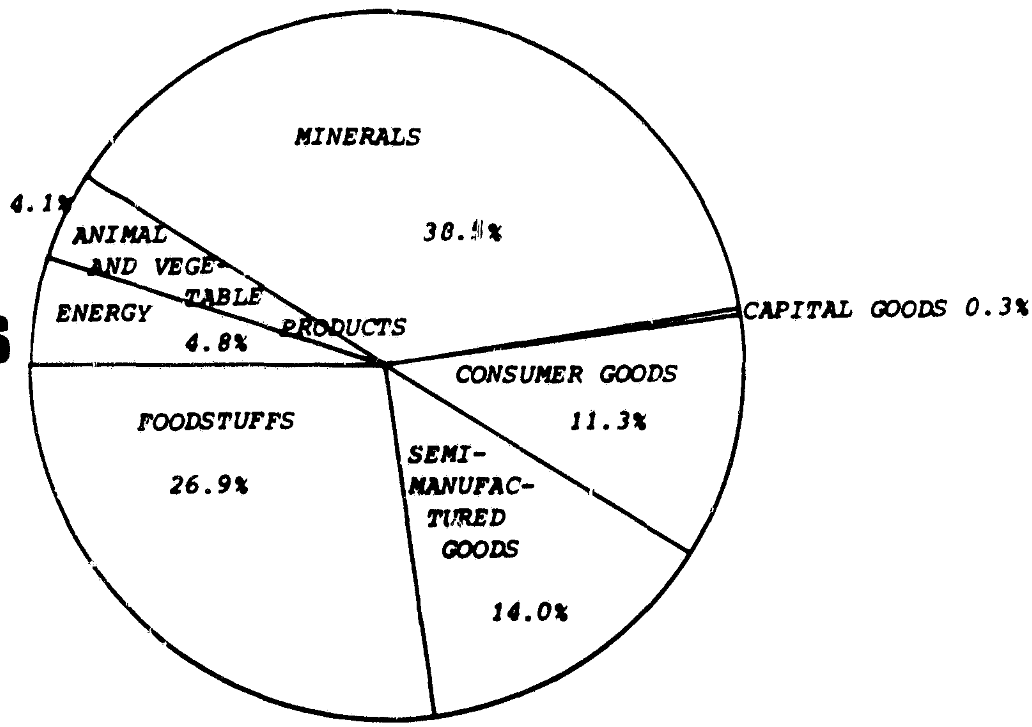
		1976	1977	1978	1979	1980
INDUSTRIAL PRODUCTION						
Volume index :						
- aggregate	% change	+ 7.2	+ 8.1	+ 6.2	+ 7.6	+ 2.9 (e)
- mining	% change	+ 5.3	+15.8	+ 6.5	+ 5.4	- 3.2 (e)
- energy	% change	+10.0	+ 4.3	+ 5.1	+30.7	+ 0.7 (e)
- manufacturing	% change	+ 6.4	+ 7.4	+ 6.3	-	+ 5.9 (e)
of which :						
.food	% change	+ 7.6	- 5.4	+21.1	+ 3.3	+ 4.3 (e)
.beverages and tobacco	% change	+ 3.7	+24.1	+10.9	- 2.6	+ 7.9 (e)
.textiles	% change	+11.0	+ 3.3	- 3.2	- 9.1	-
.chemicals	% change	+10.1	+16.4	+10.7	- 0.5	+ 3.1 (e)
Phosphate rock	'000 tons	15,656	17,572	19,272	20,032	18,824 (p)
Iron ore	'000 tons	343	407	63	62	78 (Nov)
Lead ore	'000 tons	99	156	167	165	158 (Nov)
Cobalt ore	'000 tons	7	8	9	8	6 (Nov)
Anthracite	'000 tons	702	707	720	710	710 (p)
Electricity (net)	mn kwh	3,079	3,428	3,737	4,106	4,453 (p)
Cement	'000 tons	2,117	2,604	2,819	3,318	3,672 (p)
Dwellings started :						
- estimated value	DH mn	1,424	1,877	1,701	1,664	1,077 (July)
- number		32,259	35,982	32,143	30,713	18,013 (July)
AGRICULTURE, FISHING						
Cereal harvest	'000 tons	5,703	2,880	4,714	4,074	4,506
of which : wheat	'000 tons	2,189	1,268	1,870	1,796	1,811
Sugar beet crop	'000 tons	2,362	1,474	2,399	2,175	2,189
Sugar cane crop	'000 tons	78	177	334	289	373
Citrus fruit production	'000 tons	650	798	1,077	917	1,034
Livestock	'000 head	22,600	23,734	24,247	24,800	
of which :						
- sheep	'000 head	12,375	13,771	15,272	15,604	
- cattle	'000 head	2,894	2,886	2,907	3,089	
Meat production	'000 tons			298	314	
of which : controlled slaughtering	'000 tons	105	112	116	135	103 (Aug.)
Pasteurized milk	mn liters			171	194	
Fishing produce	'000 tons	293	255	286	280	
of which : sardines	'000 tons	225	130	148	200	
MONEY, BUDGET, PRICES						
Notes and coin in circulation	DH mn	5,733	6,651	7,677	9,021	9,877 (p)
Demand deposits	DH mn	9,417	11,214	12,962	14,338	15,320 (p)
Quasi-money	DH mn	1,752	2,180	3,672	4,432	5,513 (p)
Net foreign assets	DH mn	1,838	1,812	1,779	1,648	1,533 (p)
Claims on Government	DH mn	7,935	10,116	13,561	15,428	17,262 (p)
Claims on private sector	DH mn	7,606	8,867	9,761	11,100	12,633 (p)
Budget-ordinary receipts (actual)	DH mn	8,322	10,784	11,728	13,645 (p)	
-ordinary expenditures (actual)	DH mn	8,152	9,400	10,889	13,000 (p)	
of which : public debt service	DH mn	733	1,004	1,668	2,153 (p)	
-capital expenditure	DH mn	8,121	10,306	6,520	9,016 (p)	
External public debt service	DH mn			2,065	3,160	4,000 (e)
Cost of living index	% change	+ 8.6	+ 12.5	+ 9.7	+ 8.3	+ 9.4
of which : food	% change	+ 10.3	+ 13.0	+ 8.3	+ 6.5	+ 7.9
U.S dollar exchange rates (average for year)	DH	4.51	4.50	4.16	3.93	3.95
FOREIGN TRADE & BALANCE OF PAYMENTS						
Imports of goods (cif.)	DH mn	11,555	14,401	12,361	14,328	16,796 (p)
of which : energy and lubricants	DH mn	1,303	1,669	1,782	2,769	3,718 (Nov.)
Exports of goods (fob.)	DH mn	5,579	5,860	6,261	7,622	9,633 (p)
of which : phosphates and derivatives	DH mn	2,331	2,444	2,437	2,838	3,547 (Nov)
Balance of trade	DH mn	- 5,975	- 8,542	- 6,100	- 6,704	-7,163 (p)
Government transactions (net)	DH mn	- 3,014	- 3,006	- 2,981	- 2,962	-2,350 (e)
Private unrequited transfers	DH mn	2,610	2,802	3,388	3,983	4,300 (e)
of which : workers' remittances	DH mn	2,418	2,652	3,176	3,696	4,000 (e)
Travel receipts	DH mn	1,210	1,500	1,650	1,670	1,820 (e)
Current account balance	DH mn	- 5,993	- 8,224	- 5,618	- 5,969	-5,500 (e)
Capital movements (net)	DH mn	5,941	8,206	5,592	5,764	4,900 (e)
Overall balance of payments	DH mn	- 51	- 17	- 26	- 126	- 520 (e)

MOROCCO TRADE BREAKDOWN: 1980

IMPORTS



EXPORTS



SOURCE: "Monthly Information Review," Barque Marocaine du Commerce Exterieure, No. 34, April 1981, Casablanca, Morocco.

APPENDIX D

MOROCCAN AGRICULTURE

MORROCO

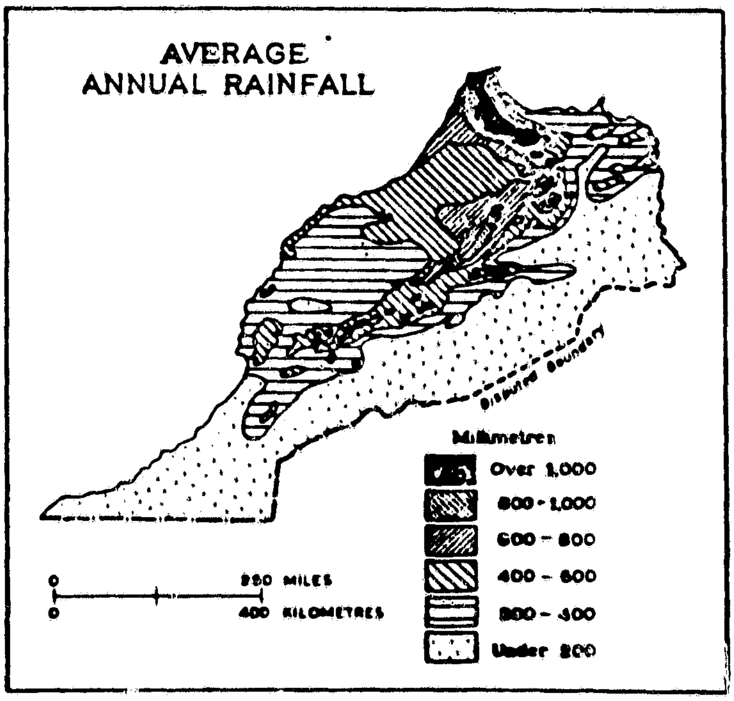
1) Climate, Agricultural Regions, and Major Domestic and Export Crops

Domestic: sugar beets & cane, cotton, wheat, barley, olives

Export: citrus, tomatoes, fish, vegetables, pulses, wine

Morocco's agricultural production accounts for about 17% of the GNP and employs 60% of the work force.

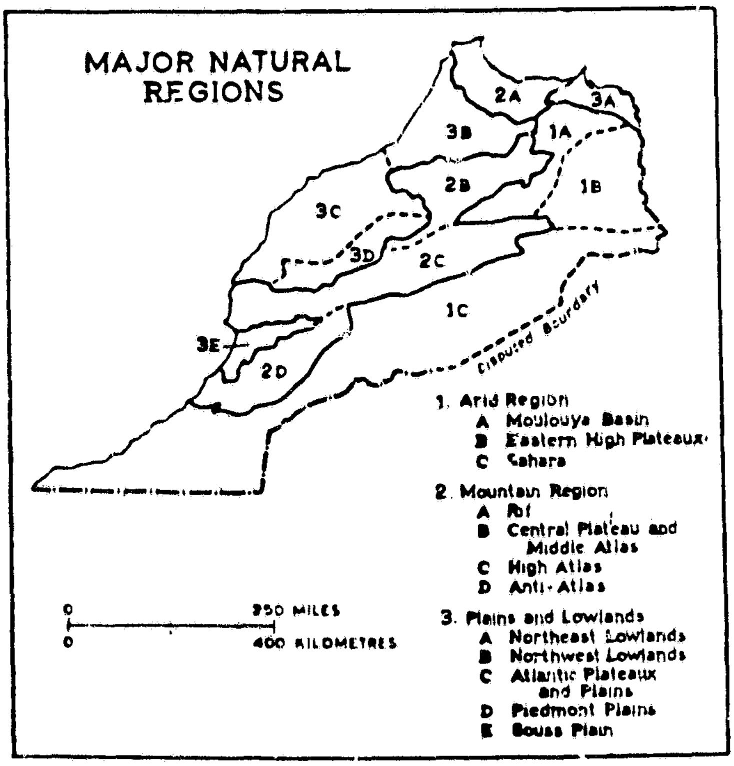
Morocco is about the size of Washington and Oregon combined. But unlike the rainy climate of these states, Morocco is drought and flood prone, and its agriculture suffers because of these climatic vagaries. Recent production has been plagued with drought since 1977. Large tracts of irrigated land have been developed, though these lands are predominately for the production of vegetables, fruits and sugar. Morocco is approaching the point of having to import 50% of its wheat requirements--the basic staple of its population--and has slipped from a position of net exporter of agricultural produce to that of net importer. Part of this is due to the failure of the agricultural sector to keep pace with population growth.



Even so, one-third of the country's total exports are agricultural. Its value in 1979 has been estimated at $423 million (citrus accounting for 30% of this figure).

Mountains cover 35% of Morocco's total land area. In the north, the Rif continue the mountain ranges of southern Spain, separated by the Strait of Gibraltar. The Atlas Mountains are more extensive and higher and run diagonally across the country. Mountain farming is primarily that of the nomads and semi-nomads. Semi-nomadic farmers combine crop farming and livestock in various proportions. Flocks and herders spend summer months in the mountains and winter at lower altitudes. Sometimes crops and gardens are owned by herders but sharecropped during their pastoral absences. Sedentary farming does take place, however, especially in the Rif and among the <u>montagnards</u> of the Atlas Mountains, where cereals, tree crops and livestock are raised. Rainfall fluctuates wildly making a precarious existence for both crops and animals.

Plateaus cover about 45% of the land area (the Moroccan Sahara being considered a vast plateau. Rangeland on the plateaux and mountains constitutes 7 million hectares, but extremes in climate make it difficult to maintain healthy flocks on sufficient pasture and water. Death, weight loss, and early slaughter are the norm. Some modern crop farming exists on the Fes-Meknes and Chaouia plateaux. But in the southeastern plateaux, traditional farming takes place on the desert oases. Here, with an average rainfall of often not more than 25mm, farmers live in villages surrounded by walls. Plots are irrigated by a spring, well, or wadi. Cereals,



vegetables, and some citrus and date palms are raised, and livestock (when kept) is moved from place to place.

Plains occupy the remaining 20% of the land. These are nearly the only areas where travel and cultivation are easy. The northwestern part of the country's plains have a Mediterranean climate with hot and dry summers and rainfall during the cool months. Irregularity of rainfall and its duration, however, often cause excessive discharge from the streams resulting in widespread flooding of basin lowlands. (Average rainfall is 500mm yearly, diminishing from north to south.) On these plains is most of the country's 7.5 million ha. of cultivable land. One-quarter of this is generally in fallow and 5% in orchard trees. Grain crops occupy the vast majority of this cultivable area. Modern farming systems are found essentially on the Rharb plain. Holdings which are large enough are mechanized with paid labor employed during harvesting. Farming, however, is not particularly intensive except in the case of irrigated crops. Yields, then, are at least 50% higher than traditional crops.

One-quarter of Morocco's cultivable land is in farm holdings having an average size of 1.6 ha. Over half the farms are under 7 ha. Ten thousand farms with cultivable land have over 50 ha. Total irrigated land in 1979 has been estimated at 500,000 ha. Regional offices monitor nine irrigated districts.

Land distribution and ownership is complex. Privately owned lands (melk) are purchased or inherited and are inequitably distributed. Ethnic groups manage collectively owned lands with redistribution among families taking place anywhere from 1-10 years, depending upon whether it is irrigated or dry land. Some religious communities hold habous lands which are generally cultivated by leaseholders. And state-owned lands are both forested and leased to tenants. Over the past five years the government has handed out to Moroccan nationals about 160,000 hectares which were formerly occupied by French or European settlers. This makes a total of over 350,000 ha. since 1966.

Forest: Forest area occupies about the same amount of land as rangeland (7 million ha.) Wood consists of evergreen oak, cork oak and cedars. Managed forest areas are used for grazing as well as for pulpwood and charcoal extraction. Between commercial wood production (primarily eucalyptus) and domestic fuelwood consumption, deforestation is occurring at an annual rate of 40,000 ha., only half of which is replanted with trees.

Fishing: Fishing has been an occupation of Moroccans for centuries. A heavy world demand for fish products and insufficient domestic markets and demand have led to a sizeable fish canning industry (150) small canneries. Total catches and landings in 1979 amounted to 260,617 MT. The dollar value of fish exports is estimated at 15% of total agricultural exports. Primary commercial production is in sardines, fish meal, and fish oil.

Livestock: Livestock raising is essentially carried out by traditional farmers, pastoralists and semi-nomads. Sheep are by far the most prevalent in numbers (13.9 million head). Pasture conditions depend, though, upon erratic rainfall and oftentimes entire flocks suffer or are liquidated.

Beef and veal are only slightly higher in slaughter weight (77,220 tons) than mutton, lamb and goat (58,500 tons). Pork plays an insignificant role in this Moslem country. Fairly modern abattoirs are located in larger cities and operated by the municipalities. Few, however, have chilling facilities or freezers, and meat is generally sold the same day it is slaughtered.

The Moroccan dairy industry is limited. Most cattle are owned by small farmers, particularly in the area between the cultivated areas and the Atlas Mountains. They are generally pastured throughout the year with a minimum of straw as a winter supplement. Straw is stacked loose and covered with a mud plaster for rain protection. All cattle, except for those on large farms or small dairies near towns, are grazed on unfenced areas under watch of herdsmen and corralled at night.

Most commercial milk supply comes from small dairies milking from a few herd to 25, the number of cows proportioned to the quantity of feed a farmer can produce. Around cities larger dairies follow modern

management practices and have as many as 100 cows. Some have pit silos, and good quality silage is fed along with dry roughage. The government has set up thirteen dairy centers in the Meknes area which serve as demonstration and training centers in dairy management. Artificial insemination is provided at no cost.

Poultry meat production is expanding rapidly with several modern facilities opened in the Rabat-Casablanca area. Commercial operators produce 70% of poultry meat; production is at 65,000 tons. Ninety percent of commercial feed production goes to the poultry industry. Traditional farmers produced some 25,000 tons in 1979 for domestic consumption or local market sales. Egg production is still predominately from traditional farmers or backyards.

2) Agricultural Development Plans

The country is currently near the end of its Three Year Agricultural Plan which is to increase production of cereals, vegetable oils, sugar, dairy, and poultry. It is also government policy to maintain wheat imports in such a way as to provide a consistent per capita consumption of this basic food staple.

Long-term agricultural goals are: to double the current land under irrigation to a total of one million hectares a 70,000 ha. increase by the end of 1980, half of which is to be under sprinkler systems); maintain a sugar self-sufficiency by 1985 (Moroccans have one of the highest per capita sugar intake proportions in the world); to obtain dairy self-sufficiency (though lately some government resources have been shifted to beef cattle); to increase the use of HYV seed strains; and, to increase tractor usage from 20,000 to 60,000.

Another long term goal is to increase export production. Ways proposed to facilitate this are: more greenhouses and freezers, quality control, and farmer extension.

U. S. AID has just initiated a $45 million dryland farming project which is to continue for five years. And the World Bank has approved a $58 million loan for the development of off-season vegetable exports.

3) Income Distribution

Morocco's present population is about 20 million people. Forty-four percent of the total population live below a $250 per capita range, including 6 million rural families. Population is increasing at a rate of over 3% annually. Because of rapid population increase, in rural areas particularly, there exists an imbalance between economic growth and demographic growth. Agricultural production is not keeping pace with birth rates and economic conditions among the rural population are tending to worsen.

The rural population is almost entirely Moslem, with 80-85% of the rural population earning a livelihood from the land. Most have to depend on inadequate resources. In 1965 the majority of rural households had an annual income below $300, which represented less than $60 per person.

4) Credit, Cooperatives and Extension Services

Credit is generally in short supply for the small farmer. Normally the farmer must have sufficient land size and productivity so loan proceeds will generate the funds for repayment. Even so, no amount of land nor modernization can insure the farmer against drought, and many have found themselves saddled with loan repayments in years when there has been little yield. Recently Morocco's Agricultural Credit Bank has added $93 million for the financing of medium-term credit operations, and the government has increased credit available to wheat farmers at harvest time.

Close to 650,000 families cultivate collectively held land amounting to around 900,000 hectares. A small percentage of arable land, and most grazing land, is collectively owned by tribes. In the cession of dominal lands and former European lands recovered by the State, the government has made cooperation and consolidation keystones of their agricultural policy. This is especially true in areas under large-scale irrigation. Cooperation and cooperatives have been promoted as an adjunct to grants of credit and other government services including land plowing and preparation.

The extension service generally lacks organization, and agents have

little practical farming experi nce. Research is excessively theoretical, and what experiments do take place are seldom under farm conditions.

5) Storage and Distribution

Due to difficult topography and transportation, internal trade follows various routes between rural areas and the large towns or export ports. Modern trading channels function through cooperatives or storage/dispatch depots. Oranges, vegetables and fish, for example, are often sent direct from the producing or catching area to the conditioning plant which then ships them to Europe. The State livestock development company operates silage units and animal feed plants. The government is focusing attention currently on the financing of wheat purchasing centers and marketing and distribution infrastructure. Total storage capacity for wheat (the only grain in storage ouside of units) is 600,000 tons in storage cooperatives and 140,000 tons in port silos.

Traditional trading channels are more complex. Usually the farmer takes his produce to the weekly rural market (souk). There his crops pass through the traditional merchants and wholesalers to reach the towns and larger urban centers. Crops grown for domestic consumption, especially cereals and pulses, are dried in the sun (often on rooftops) before being stored. Over 8,000 small flour mills are scattered throughout the country grinding grain for local use.

6) Agricultural Production

Over eighty percent of crop or tree-planted land is cultivated, and 95% of the livestock is produced, by traditional methods by small landholders. Modern farming methods are used on 10-15% of the cultivable land. These farms contribute 25% of all crops by value, and 85% of the export crop production.

Cereals and pulses are the leading products of Moroccan crop farming both in area and production. They are grown as a dry crop on the plains and found up to 2,000m altitude in the mountains, and as an irrigated crop in the east and south. More than 50% of the farms (one million families) that produce wheat and barley have less than 5 ha. of cultivable land and use traditional methods.

Barley

30% of arable land devoted to this crop; production of 1,886,000 MT.

Barley is consumed domestically (no exports) at a production of 1,886,000 tons. It is the most available and cheapest feed in both the commercial and traditional livestock sector (36% of production going into feed). Barley is the leading cereal, occupying more than half of the total area sown to cereals. It is both a hardy cereal which can resist drought and low mountain temperatures, and a heavy yielder. Almost all production of barley is in the hands of traditional cultivators.

Wheat

25% of arable land is devoted to wheat; Morocco imports wheat--its number one agricultural import (about 1,500,000 tons--and produces 1,800,000 tons).

Hard wheat, or durum, is the predominant wheat grown (70%) mostly on the plains of the northern Atlantic seaboard by traditional farmers. Soft wheat, or bread wheat, has increased in area and production lately and is cultivated primarily by modern farmers. Morocco's estimated 3,000 harvester/threshers in use are mostly for production of this crop. For the 1980 crop some 50,000 tons of HYV wheat seed is expected to be distributed to wheat farmers, a 100% increase over 1979.

Pulses

6% of arable land devoted to this crop; production is 262,000 tons; Morocco's only grain and feed export (about 21% of production) brought $22.8 million export dollars.

Pulses are produced by both modern and traditional farmers and are a traditional dietary staple. The most important pulses are broad beans, chickpeas and lentils. Peas and haricot beans are cultivated primarily on

modern farms where they play an important rule in cereal/bean crop rotation.

Vegetables

undetermined % of arable land, probably less than 1%; a production of 1,200,000 MT.

Truck gardening is carried out near Morocco's large cities. About 8,000 commercial vegetable farms with intensive use of irrigated land produce high yields and employ thousands of agricultural workers. Most vegetables are raised for early export to Europe, or for the canning factories. Tomatoes make up about two-thirds of the processed canning production of Morocco during the three summer months.

Citrus

1% of arable land devoted to this crop; fresh citrus exports amounted to 615,000 MT and over $150 million in export value.

Citrus production has expanded rapidly in cultivated area and in exportation. Although the yield is variable, usually averaging better than 120 quintals per hectare, there is sufficient return on investment to support the modern farms where the trees are chiefly grown. Citrus production demands a high labor input and employs over 100,000 persons. The conditioning and packaging of the fruit has given rise to local artisan industries.

Most citrus production is in the Rharb and Souss regions.

Sugar

Most production comes from the sugar beet with about .6% of arable land devoted to its cultivation; sugar beet production is slightly over 2 million MT; sugar cane production close to 300,000 MT.

Sugar beet cultivation was begun in 1959 in the irrigated area of the Rharb under a French and Belgian group. Production and yield figures led immediately to increased hectares devoted to this crop, and the construction of sugar refineries. With Moroccans' high sugar intake, (importation of sugar in 1978 cost Morocco $80 million) cultivation of this crop has meant a major savings in foreign exchange (sugar cane production wasn't begun until 1975).

Morocco has five sugar mills now with more under construction. The sugar industry is controlled by the government. Farmers are assured of fixed prices and must deliver to designated mills.

Vegetable Oils

area devoted to oil seeds is about 20,000 ha.; production of about 40,000 MT of oil (35,000 from olives and the remainder from oilseeds, such as sunflower, cottonseed, peanut and soybean).

Moroccans consume about 165,000 tons of oils and butter, seed oil accounting for 84%. Understandably, the government's goal is to progressively reduce imports. Oilseed crushing capacity in Morocco is estimated at 200,000 tons, meaning that units are now operating far below capacity.

Olives remain essentially a product of traditional farmers. Most of the harvest is processed into olive oil (increasingly in modern mills, but still processed by artisan oil mills producing acidic oil).

Cotton

area planted has decreased to 8,400 ha.; raw cotton production at 10,860 MT.

Cotton is the chief textile crop and production is concentrated in large irrigated zones, particularly in central Morocco. Hectares are farmed intensively, an overall yield of 13 quintals per hectare, and spray planes are used for dusting the crop.

Grapes

about 1% of the arable land is devoted to vineyards; production of 215,000 MT of grapes and 114,000 MT of wine at an export value of over $11 million.

Vineyards were developed by the French during the colonial period. Traditionally grapes were grown in this Moslem Country for table grapes and raisins. Traditional vineyards have been generally ill cared for, but the recent increase in export opportunities and higher prices have revitalized production and an ambitious re-planting program is underway.

Traditional Farming

Though traditional agricultural practices differ throughout the country according to rainfall, topography and tribe, the following description of agriculture amongst tribes in the Rif will serve to indicate the state of tools and implements, diversification of crops and harvesting and storage methods within this sector of the agricultural population.

In January farmers prepare their land by hand or with cattle and plough. Barley is sown and pulses planted by hand. About the first of March, mountain slopes are hoed and rye sown and peas planted. Then begins work on vegetable gardens (potatoes, beans, carrots, turnips, onions and peppers) and roots around fruit and nut trees and vines are dug around, manured (often carrying this laboriously up slopes) and vines pruned.

Toward the beginning of June pulses are pulled by hand, and laid aside for threshing, barley is cut with sickles, and terraces irrigated for planting corn. The crops reaped are threshed with cattle, donkeys or mules, which are forced to trot around a circular threshing floor. Then rye is cut and threshed by hitting the heads of the sheaves against sticks held in the hand. (It is tabu to thresh rye with cattle or to plant it by means of animal or the plough.) In July the maize is reaped, terraces watered and a second quick-growing maize crop planted.

Almonds and walnuts are picked and stored away, and the vegetables from the garden are gathered and more seeds and tubers planted. Toward late August, figs are picked, split and set to dry.

September is grape season. Grapes are picked, the women gather a root (fathis) which they burn and the ashes are mixed with water to wash the grapes, then they are set out to dry and form raisins. Olives are next picked and stored away in salt until there is time to grind them. (Olives can be stored for two years in this manner.) November is wood gathering time and December, if one possesses orange trees, is the time to pick fruit. Some is eaten, but much is sold in the market.

In regions where there is no terraced irrigation, only one crop of maize and one crop of vegetables are raised.

Tools are primitive and the ariyzim, or hoe, is the primary implement. Turbine grain mills, in small houses built over the end of a high-flowing irrigation ditch, are very common as are ordinary hand mills. Olives are put into a grinder where the wheelstone is turned by men or animals. Oil is pressed by a log and screw affair. Irrigation ditches must be carefully constructed and cared for; where sides of the valley are precipitous, ditches are often led around through hollowed olive logs.

Special crops

Almost one-third of the export value of forest products come from these three:

cork is the raw material for processing industries concentrated along the coast between Tangier and Casablanca;

esparto grass is collected traditionally and exported;

vegetable horsehair is obtained from the dwarf fan-palm. Morocco is the leading producer and world exporter.

MOROCCO

Agricultural development needs as they relate to....................	possible p/v applications
drought prone	irrigation
most of fish canned and exported	refrigeration for domestic markets
planned expansion of dairy and poultry	incubation - brooder houses dairy operations
planned expansion of green-houses	p/v powered motors for fans in air circulation and sterilization of soil
95% of livestock kept by smallholders	mobile milk collection
grains are staples	threshing and milling
olives	grinding and press

SOURCES

AID, 1979, Project Paper "Morocco: Renewable Energy Development."

Coon, Carleton Stevens, *Tribes of the Rif*, Harvard African Studies, Volume IX, Kraus Reprint Co., 1970.

International Association of Agricultural Economists, *World Atlas of Agriculture*, Instituto Geographico de Agostini, Novara, 1976.

Kurian, George T. (Ed.) *Encyclopedia of the Third World*, Facts on File, New York, 1978.

Nyrop, Richard F., *Area Handbook for Morocco*. Foreign Area Studies of American University, 1972.

Rouse, John E., *World Cattle*, Vol. II, University of Oklahoma Press, 1972.

Stewart, Charles F., *The Economy of Morocco: 1912-1962*, Harvard Middle Eastern Monographs XII, Harvard University Press, 1964.

USDA, Agricultural Situation: Review of 1978 and Outlook for 1979, "Africa and West Asia."

USDA, Foreign Agricultural Service, "Attache Report" on Morocco's Agricultural Situation, January 1980.

Monthly Insolation Values in Tens of Calories Per Square Centimeter - Casablanca/ANFA Auport*

Stations	Jan.	Feb.	Mar.	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Year
1970	694	943	1252	1662	1842	1698	1932	1766	1367	1056	730	630	15570
1971	718	909	1223	1389	1579	1838	1824	1719	1440	1150	705	624	15118
1972	703	840	1231	1546	1845	1817	1867	1686	1371	990	819	682	15402
1973	766	887	1140	1592	1807	1722	1950	1603	1482	1102	776	658	15436
1974	792	895	1186	1427	1738	1737	1839	1819	1480	1198	768	728	15608
1975	714	887	1305	1453	1740	1870	1949	1737	1507	1211	856	592	15821
1976	806	937	1341	1413	1530	1633	1794	1796	1428	1034	818	579	15109
1977	713	859	1424	1604	1762	1887	1863	1700	1330	956	730	504	15332
1978	626	754	1269	1482	1669	1623	1768	1716	1337	1111	769	594	14718
1979	619	773	1164	1453	1534	1602	1645	1536	1320	971	822	682	14127
1980	773	846	1130	1478	1784	1686	1828	1614	1218	1072	745	704	14998

*Using Eppley Pyroheliometer

SOURCE: Meteorologie Nationale

APPENDIX E

SOLAR INSOLATION DATA

(HOURS OF SUNSHINE/MONTH)

METEOROLOGIE NATIONALE
A.M/M.M

—— A L - H O C E I M A - A E R O —— (Côte du RIF)

DUREE DE L'INSOLATION MENSUELLE (en heures et 1/10) Date :

HOURS OF SUNSHINE/MONTH

STATIONS ANNEES	Altitude en mètres	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNEE
[illegible]		[illegible]	[illegible]	[illegible]										
1964		188.3	184.0	270.5	271.4	317.1	312.6	336.8	332.0	240.3	253.2	194.6	198.8	3033.9
1965		145.8	159.1	253.7	258.2	(349.4)	334.2	328.4	336.3	264.6	193.9	170.8	208.2	2997.2
1966		196.2	201.6	276.0	300.1	303.6	353.6	326.6	345.4	(265.6)	(2[illegible].2)	(210.9)	227.9	3230.7
1967		(214.5)	(157.6)	244.1	214.4	272.0	264.3	322.0	310.2	259.2	251.9	193.2	167.5	2830.9
1968		249.3	140.9	166.5	204.0	301.7	308.4	XX	XX	XX	XX	96.2	172.9	1633.9
1969		174.4	94.9	202.2	218.6	(255.3)	311.8	312.7	329.8	249.6	191.7	138.2	174.7	2641.9
1970		(144.8)	228.6	200.3	270.0	283.9	303.0	342.0	264.7	229.4	229.7	174.0	172.4	2892.8
1971		190.6	222.9	186.8	193.6	234.8	(329.8)	313.8	292.1	261.6	254.6	189.6	175.9	2806.1
1972		(169.1)	166.5	(229.9)	299.8	312.6	299.5	335.2	(306.7)	227.3	194.9	205.2	208.5	2950.2
1973		225.1	197.4	207.7	265.4	283.1	(362.8)	317.9	298.3	306.3	245.8	125.3	166.7	2941.8
1974		236.8	183.5	216.5	216.5	323.9	242.0	278.4	299.7	267.0	234.4	193.3	243.8	2935.8
1975		189.4	165.1	212.7	166.6	231.5	284.2	280.1	261.3	233.0	234.5	200.7	173.5	2632.6
1976		229.7	192.0	248.2	197.8	220.2	268.6	292.8	279.8	244.7	221.8	216.1	141.8	2753.9
1977		148.5	188.8	224.7	255.7	270.4	315.1	304.0	312.1	264.7	223.5	207.8	138.6	2855.9
1978		158.2	195.3	275.2	245.9	273.5	263.5	319.5	257.5	271.0	232.4	228.2	182.9	2903.1
1978		149.8	(166.9)	249.8	296.4	282.9	286.0	253.7	299.4	220.1	170.9	(229.1)	212.0	26[illegible].0

Imp. Météo. Nle. Casa. N° 218 (er)

-=- B E N I - M E L L A L -=-

METEOROLOGIE NATIONALE

DUREE DE L'INSOLATION MENSUELLE (en heure et I/IO)
X = PAS DE RELEVES

Date :

HOURS OF SUNSHINE/MONTH

/H.M

STATIONS	Altitude en mètres	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNEE
I969		X	X	X	X	X	X	X	X	X	235.2	I65.I	I9I.4	
I970		I55.4	208.3	I75.2	299.4	(3I3.2)	290.I	352.0	3I7.4	280.I	242.7	I93.I	I75.2	(3002.7)
I97I		I90.7	230.6	208.2	I59.5	204.2	297.4	35I.8	3I6.3	299.9	273.02	268.9	2II.I	292I.6
I972		202.0	I66.0	22I.0	279.4	273.0	X	36I.3	337.0	27I.7	2I6.3	I98.5	289.6	27I6.4
I973		2I6.6	204.9	220.2	25I.2	303.9	3I3.9	35I.2	325.I	322.6	255.2	I97.3	204.3	3I70.4
I974		267.0	2I8.I	2I7.3	I78.I	278.8	305.4	363.2	353.6	285.7	275.3	239.2	24I.I	3222.8
I975		2I5.I	I98.2	264.I	22I.I	277.4	338.4	339.5	347.I	265.9	30I.6	244.7	I78.5	3I9I.6
I976		258.4	220.0	260.9	22I.5	2I3.3	3I0.9	340.8	228.6	29I.8	230.8	246.9	I6I.6	3085.5
I977		I48.0	I9I.5	27I.9	278.8	296.8	369.5	396.0	354.7	283.2	232.0	23I.2	I66.9	3220.5
I978		I96.2	I92.I	29I.2	242.7	307.7	325.3	384.0	327.7	288.8	279.2	237.0	205.3	3277.2
I979		I69.8	I86.3	232.5	326.6	296.9	299.5	3I0.3	370.8	279.7	I93.I	264.0	240.5	3I70.0

Impr. Météo. Nle. Casa. N° 218 fèv.

A.M/H.H

-*- C A S A B L A N C A - A N F A -*-

DUREE DE L'INSOLATION MENSUELLE (en heures et I/IO)
HOURS OF SUNSHINE/MONTH -*-

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUELLE
I955	I55.5	I74.4	I93.8	287.3	3I6.7	3I9.7	303.I	3II.I	287.0	23I.7	I5I.0	I99.5	294I.0
I956	I72.I	I42.3	206.3	269.4	309.6	305.0	356.6	307.I	283.8	238.8	I78.2	209.5	2958.7
I957	I78.5	I59.5	2I2.7	I98.I	253.0	255.9	325.0	259.9	255.2	202.I	I69.4	I35.9	2587.2
I958	I43.[illegible]	I48.5	24I.2	24I.7	29I.I	259.5	332.I	30I.2	266.6	24[illegible].9	I59.5	I38.8	2835.0
I959	I[illegible]I.3	I65.5	2I5.7	285.2	269.5	273.0	259.7	307.5	300.5	232.5	I64.5	I60.5	2856.5
I960	I38.0	I77.5	222.7	3I2.0	255.3	254.9	334.6	335.5	288.6	232.2	234.0	I45.6	2944.2
I96I	I49.9	227.4	282.6	253.9	323.4	304.3	309.9	336.7	250.I	25I.2	I40.4	I9I.7	303I.5
I962	I84.9	229.4	(I86.I)	264.8	287.6	256.6	308.6	292.5	260.4	I93.2	I76.8	I65.5	2846.5
I963	I25.3	I42.8	275.5	263.3	279.2	289.4	3I4.I	264.5	277.9	242.4	I64.3	I27.6	2787.3
I964	I59.4	203.8	223.3	25I.9	284.6	292.7	282.I	289.I	2I9.I	235.2	I75.4	I59.4	2827.0
I965	I45.7	I68.5	22I.2	245.5	3I6.4	284.9	3I5.5	288.0	255.5	I88.2	I57.I	I57.2	2756.9
I966	I89.6	I87.6	254.9	303.2	280.4	307.8	280.4	302.5	284.9	I94.2	I78.6	I98.7	2962.[illegible]
I967	I99.9	I82.2	226.8	2I4.4	276.0	300.4	(295.2)	309.4	25I.0	2I2.9	I52.4	I6I.[illegible]	278I.[illegible]
I968	207.7	I62.7	I89.3	232.3	3I3.7	298.2	3II.5	290.3	282.8	24I.2	I50.4	I56.9	2847.[illegible]
I969	I82.9	I35.2	242.8	22I.7	3I2.5	287.5	325.5	3I0.7	27I.3	258.5	I55.7	I77.4	289I.[illegible]
I970	I55.5	208.6	226.8	298.9	303.4	237.7	328.7	3I5.5	263.6	222.7	I87.9	I80.I	2929.4
I97I	I84.6	230.6	232.7	244.4	259.2	3I2.3	307.I	(298.4)	287.9	259.I	I7I.4	I82.I	2942.8
I972	I7I.8	I82.7	234.6	285.I	328.5	X	30I.6	273.5	26I.5	2I5.5	220.4	(I85.5)	2560.9
I973	206.8	203.3	222.3	309.9	3II.3	278.2	343.2	278.0	300.3	249.2	2I4.8	I89.I	3I0[illegible].4
I974	(225.6)	209.I	206.2	234.5	25I.3	277.5	299.4	3I8.9	270.7	(266.6)	(I36.0)	220.8	(295[illegible].6)
I975	I87.4	I98.4	240.3	235.3	259.6	28I.5	328.I	32I.5	288.8	(272.8)	229.8	I59.2	(3002.7)

ORIGINAL PAGE IS OF POOR QUALITY

ORIGINAL PAGE IS OF POOR QUALITY

A.M/E.M

-•- EL AYOUNE -•-

DUREE DE L'INSOLATION MENSUELLE (en heures et I/IO)
X = pas de relevés

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUEL
I960	X	X	X	X	X	X	29I.I	300.2	[illegible]	I99.5	243.3	I65.3	
I96I	244.3	25I.7	227.0	250.8	255.I	25[illegible]	I77.0	265.0	22[illegible]	I54.6	I60.[illegible]	249.	2754.5
I962	209.6	235.7	264.4	272.I	265.5	3I4.5	264.3	27I.[illegible]	253.3	2I5.2	220.6	205.5	3057.0
I963	I95.8	2I5.3	29[illegible]	265.0	3I7.2	30I.5	30[illegible].3	259.3	2I8.3	222.3	226.8	200.8	3053.8
I964	258.I	244.[illegible]	259.4	270.2	3I2.6	303.I	255.3	259.0	239.0	2I9.3	235.7	2I4.2	3I00.I
I965	I8I.7	220.I	245.5	220.5	258.0	293.I	305.3	270.6	263.5	279.9	273.0	X	28I2.3
I966	24I.9	273.4	324.3	323.5	252.8	244.[illegible]	260.5	22I.6	267.0	249.0	224.3	29I.8	3I34.9
I967	2[illegible].2	234.4	247.6	235.5	276.3	X	264.6	27I.I	255.4	260.4	229.3	236.I	2637.9
I968	254.4	246.[illegible]	265.I	290.0	325.7	276.6	292.9	293.	256.4	227.[illegible]	250.2	239.I	32I[illegible].9
I969	277.0	240.6	276.9	260.9	296.4	236.3	236.2	302.[illegible]	I65.3	239.0	I75.[illegible]	I70.0	25I7.0
I970	255.8	I59.8	2I9.6	269.3	3I6.6	29I.5	292.0	2[illegible].5	224.5	254.9	207.[illegible]	229.9	30[illegible]I.4
I97I	247.6	2[illegible].2	227.0	257.4	300.9	329.5	259.6	[illegible]	267.3	224.0	I[illegible].6	I98.3	304[illegible].4
I972	23I.5	2I9.6	246.2	259.6	3I[illegible].3	290.2	306.I	304.7	X	X	X	2I2.2	2390.6
I973	257.I	I7[illegible].I	X	X	X	2[illegible].I	263.5	256.I	272.[illegible]	239.2	227.6	2II.4	2I95.0
I974	277.7	233.0	247.2	306.5	2[illegible]5.4	260.5	275.0	265.5	240.6	235.3	20[illegible]	23I.9	3I0[illegible].6
I975	22I.6	2I9.9	256.8	267.0	295.5	267.6	237.9	27I.5	207.8	236.2			

METEOROLOGIE NATIONALE

A.M/H.M

-=- KSAR - ES - SOUK -=-

DUREE MENSUELLE DE L'INSOLATION (en heures et I/IO)

HOURS OF SUNSHINE/MONTH

Date :

STATIONS	Altitude en mètres	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNEE
I973		IO7.I	I63.0	(224.4)	274.4	3I4.7	294.2	3I4.6	294.4	298.2	298.8	200.2	248.2	(3032.2)
I974		276.0	(27I.9)	27I.2	265.7	322.9	339.2	324.8	306.4	277.0	297.6	255.I	240.0	(3447.[illegible])
I975		(258.4)	243.8	X	276.I	3I5.2	36I.4	X	330.5	274.9	305.0	X	X	
I976		26I.I	264.6	266.7	270.5	X	305.0	353.7	X	(264.6)	279.3	26I.9	240.5	
I977		25I.8	252.I	3II.6	272.5	30I.I	362.9	332.8	269.7	X	258.I	260.8	200.2	3073.[illegible]
I978		220.6	240.5	3I9.4	303.9	353.3	358.7	328.I	252.6	288.5	255.2	257.4	249.4	3427.[illegible]
I979		I78.4	237.0	283.5	326.2	288.3	3I6.8	285.4	274.6	244.3	2I8.7	276.3	260.9	3I87.4

Imp. Meteo. Nle. - Casa. - N° 218 ter

ORIGINAL PAGE IS OF POOR QUALITY

A.M/H.M

-=- E S S A O U I R A -=-

D REE DE L'INSOLATIO MENSUELLE (en heures et I/I0)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	
I960	I90.7	223.2	259.I	305.3	3I4.I	254.4	330.7	328.9	273.7	237.6	I83.5	I9I.0	3I26.0
I96I	203.5	230.8	254.3	302.3	279.8	303.3	3I5.5	299.5	255.4	243.I	I77.4	203.2	3079.I
I962	229.2	240.0	I86.0	240.0	259.9	327.4	340.7	3I3.2	255.6	247.6	2I7.4	20I.0	3II6.0
I963	I52.2	2I3.0	302.I	280.I	29I.2	3I6.5	320.2	30I.9	3II.I	265.0	242.6	I6I.3	3I65.2
I964	220.3	240.5	259.4	265.6	3I0.6	320.3	365.8	328.0	257.7	259.9	227.0	I98.5	3243.7
I965	2I2.9	209.7	294.2	30I.I	349.5	323.2	398.8	309.7	285.4	2I3.0	2I9.9	243.7	336I.I
I966	223.I	230.5	289.I	323.6	294.4	284.5	328.I	322.2	264.0	248.5	282.3	235.2	3245.6
I967	223.I	2I7.7	28I.8	228.2	3I0.2	33I.4	343.0	32I.6	27I.4	252.9	I5I.3	229.4	3I72.0
I968	25I.I	203.3	223.0	259.4	300.0	3I5.3	XXX	XXX	I88.I	200.2	XXX	209.2	2I50.6
I969	200.7	I43.2	203.4	234.7	272.6	237.I	276.4	280.9	238.8	200.2	II7.5	I64.0	2569.9
I970	I38.8	I72.0	I76.5	(255.2)	255.2	275.0	285.3	252.6	243.4	I72.5	I88.5	I25.3	255I.I
I97I	I65.6	I56.9	229.5	237.2	275.4	309.I	305.9	30I.I	257.0	243.0	I35.4	2I4.5	2870.5
I972	20I.7	I39.3	224.8	253.6	297.I	32I.8	320.2	25I.9	276.0	2I6.8	2I3.5	I83.3	3002.I
I973	I96.9	220.4	238.3	292.8	286.I	266.I	3I7.I	28I.0	252.3	234.3	I8I.5	I85.7	3028.5
I974	246.I	I76.3	2I3.6	249.2	253.8	236.2	203.0	253.2	2I3.0	257.2	206.2	I7I.3	2673.I
I975	X	I90.3	259.2	204.I								I59.0	

— F E S - S A I S —

[illegible] MENSUELLE DE L'INSOLATION (en Heures et I/IO)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUEL
I96I	X	X	(256.9)	[illegible]	[illegible]	262.4	344.4	[illegible]	[illegible]	22I.7	I28.5	I62.[illegible]	24[illegible].4
	I78.8	205.7	I53.5	[illegible]	[illegible]	279.9	324.5	[illegible]	[illegible]	I63.7	I32.5	I43.0	2536.0
I963	II9.6	III.0	259.[illegible]	[illegible]	[illegible]	27[illegible].5	358.7	[illegible]	254.3	278.[illegible]	I92.0	I0I.I	2706.5
I964	I93.0	I09.9	I99.8	[illegible]	328.0	263.9	335.3	32[illegible]	[illegible]	25I.8	I7I.5	I40.I	26I7.I
I965	II3.5	I43.8	[illegible]	[illegible]	3[illegible].0	299.8	3[illegible]2.8	2[illegible]5.2	[illegible]	I82.I	I5I.5	I52.5	2628.7
I966	I90.5	I67.5	265.7	[illegible]	[illegible]23.2	3I9.3	339.4	334.[illegible]	2[illegible]4.[illegible]	I93.4	I90.[illegible]	225.3	3I3I.9
I967	227.7	I78.3	26I.5	2I5.4	2[illegible]3.2	3[illegible]	3[illegible]4.9	33[illegible]	[illegible]	2[illegible]6.7	I55.0	I7I.[illegible]	2960.2
I968	265.2	I45.6	I[illegible]I.4	I[illegible]6.5	[illegible]	3I8.6	336.5	[illegible]	3[illegible]5.7	276.[illegible]	I33.2	I50.9	2657.0
I969	I7I.5	I[illegible]3.[illegible]	I95.[illegible]	I[illegible]3.2	[illegible]23.[illegible]	255.[illegible]	350.[illegible]	[illegible]3[illegible].5	[illegible]	202.5	I36.9	I5[illegible].[illegible]	256[illegible].4
I970	I40.[illegible]	2[illegible].0	I79.[illegible]	300.I	[illegible]74.[illegible]	25[illegible].7	37[illegible].7	[illegible]3.7	2[illegible]5.4	[illegible]34.5	I97.2	I53.3	2943.0
I97I	[illegible]7[illegible].2	2[illegible].5	20I.[illegible]	I77.7	I[illegible]9.3	29I.4	339.6	3[illegible].7	2[illegible].3	277.0	I4[illegible].I	I7[illegible].I	27[illegible].7
I972	I45.7	I30.5	I72.5	2[illegible].0	23[illegible].2	2[illegible]I.2	333.2	33[illegible].[illegible]	354.[illegible]	207.2	I9[illegible].0	I95.I	2763.2
I973	I[illegible].5	I0I.5	I[illegible].2	252.I	2[illegible].3	286.5	372.7	325.4	3I5.5	246.7	I75.2	I47.[illegible]	2[illegible]2.[illegible]
I974	(253.I)	I5I.2	I[illegible]7.4	(I42.0)	(2[illegible]3.[illegible])	X	X	33[illegible]	2[illegible].4	(237.3)	2[illegible]4.9	23[illegible]	230[illegible].4
I975	I76.7	I[illegible].6	202.9	I7[illegible]	I[illegible].7	[illegible].3	2[illegible].3	[illegible].7	[illegible]	[illegible].4	[illegible]	I64.4	27[illegible].0

ORIGINAL PAGE IS OF POOR QUALITY

- / MA

- IFRANE - AERO -

- Durée de l' Insolation Mensuelle (en Heures et 1/10))

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL
1958	156.5	177.6	233.4	251.9	318.5	363.6	414.5	327.5	291.5	252.9	172.4	110.4	3112.7
1959	205.3	[illegible]	211.0	282.5	[illegible]	339.7	317.2	350.2	284.5	231.7	183.4	174.5	3026.5
1960	158.5	183.9	170.1	295.7	[illegible]	291.2	365.0	315.2	297.5	194.1	187.5	111.1	2871.2
1961	160.2	245.0	243.0	270.5	241.4	270.6	329.1	340.7	263.1	246.1	110.4	171.9	2872.0
1962	201.7	197.9	105.4	209.3	249.1	256.1	330.9	233.1	225.7	162.2	141.8	115.9	2519.1
1963	57.5	70.9	256.7	184.6	194.7	[illegible]	352.4	307.7	269.1	276.7	200.0	83.3	2509.7
1964	162.3	193.4	187.2	179.5	316.1	275.3	335.3	331.0	179.1	233.3	146.0	121.9	2660.5
1965	100.4	123.1	189.7	211.9	346.0	292.1	345.8	331.0	235.5	150.6	157.6	192.6	2631.3
1966	204.0	152.8	250.1	274.0	305.8	314.5	357.2	330.5	267.2	163.6	162.3	240.9	3049.7
1967	232.2	159.9	275.7	175.3	247.2	250.0	347.1	310.8	267.9	211.6	123.6	139.8	2790.1
1968	202.9	114.6	145.9	196.6	280.3	314.9	329.7	325.9	311.1	277.9	117.8	133.3	2759.9
1969	157.1	[illegible]	170.8	189.5	263.1	266.2	365.3	363.4	268.7	179.7	139.5	139.1	2596.7
1970	119.1	237.0	160.1	201.3	297.2	291.2	307.6	348.2	273.5	235.1	191.3	153.2	[illegible]
1971	(179.4)	219.6	177.2	157.5	165.4	304.1	372.4	(323.0)	(306.1)	270.0	152.5	161.5	(2708.7)
1972	[illegible]	112.6	166.3	(263.5)	(253.3)	344.3	369.5	(343.2)	222.6	202.3	172.2	195.2	(2789.3)
1973	192.8	175.0	178.4	239.4	(304.4)	339.4	367.1	(299.8)	315.9	239.2	173.0	120.4	(2954.0)
1974	(251.1)	177.0	136.9	126.2	291.3	274.1	(323.4)	322.8	265.3	(233.7)	221.9	253.4	(2530.9)
1975	190.2	175.1	137.2	160.5	224.6	314.2	310.4	313.0	249.8	283.7	(204.3)	151.1	(2700.9)

METEOROLOGIE NATIONALE

— K A S B A - T A D L A —

Durée de l'Insolations Mensuelle (en heures et 1/10)

Date :

HOURS OF SUNSHINE/MONTH

ANNEES	Altitude en mètres	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	Totale ANNEE
1961		192.8	272.7	280.7	308.1	298.3	336.5	359.4	344.2	288.0	279.6	161.7	213.2	3332.8
1962		220.7	230.6	175.3	259.5	302.3	357.8	371.0	328.1	268.8	212.7	172.7	196.3	3092.8
1963		133.8	132.8	287.0	242.7	226.0	330.9	381.0	324.6	291.6	289.8	224.7	136.7	3001.8
1964		190.6	221/9	236.0	218.7	364.9	309.4	357.2	340.4	244.3	274.1	232.7	187.7	3170.9
1965		177.2	173.8	241.3	253.9	348.9	344.3	362.1	333.4	289.9	212.8	219.7	214.6	3170.9
1966		242.5	229.2	299.2	331.9	330.9	35?.1	387.4	(378.?)	298.2	236.8	218.2	280.6	(3383.9)
1967		266.5	187.1	300.9	233.6	291.3	362.3	366.8	390.5	302.1	266.0	186.2	204.3	3317.6
1968		266.5	183.2	189.3	243.9	324.6	356.4	377.5	355.2	340.8	300.1	158.2	179.5	3275.2
1969		218.1	127.8	207.2	197.3	296.2	287.7	385.9	374.4	285.6	249.2	159.5	(193.2)	2981.8
1970		(151.5)	224.9	190.9	308.5	306.3	304.7	399.2	352.0	X	237.9	195.3	185.5	(2896.7)
1971		191.3	244.6	223.4	165.2	187.8	318.0	378.6	329.6	326.7	287.9	166.1	212.5	3001.7
1972		208.0	167.1	233.2	301.0	269.6	359.6	383.0	station fermée					

Imp. Météo. Nle. Casa. N° 218 Fer.

-*- K E N I T R A -*-

DUREE DE L'INSOLATION MENSUELLE (en heures et I/IO)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL
I958	I88.7	I83.5	247.3	272.2	3I5.2	3I7.9	385.4	332.9	293.4	267.0	I97.6	97.7	3098.8
I959	206.7	204.5	203.3	297.5	273.8	323.7	327.8	326.9	305.3	255.7	I80.0	I27.2	3039.4
I960	I2I.0	I75.6	I99.I	276.5	306.2	267.8	339.5	33I.9	296.0	2I2.I	I82.6	I36.2	2864.5
I96I	I22.7	203.8	268.9	256.4	296.5	298.8	34I.0	322.4	253.7	234.0	I23.7	I57.8	2809.7
I962	I67.2	2I7.I	I8I.3	252.I	282.6	305.6	343.6	323.0	26I.8	207.4	I7I.4	I33.2	2845.3
I963	I0I.3	I3I.3	260.5	268.8	257.6	295.3	349.2	303.8	267.9	247.7	I46.I	II7.I	2746.6
I964	I63.5	I64.4	I93.0	237.9	298.3	296.2	306.9	293.I	2I0.6	I95.4	I07.4	II3.2	2597.9
I965	I04.8	I57.I	I94.2	254.3	320.0	3I5.8	35I.5	3II.4	272.2	I66.I	I44.9	I28.0	2720.3
I966	I48.7	I89.I	268.I	307.6	305.6	33I.6	3I2.6	322.7	299.I	206.4	I9I.3	I92.5	3075.3
I967	I9I.9	I59.9	26I.5	246.0	307.0	337.5	329.8	327.8	27I.9	226.5	I60.8	I56.8	2978.0
I968	I83.8	I43.6	I77.8	237.0	297.4	3I2.7	3I5.I	293.5	280.0	230.8	I36.3	II9.4	2727.4
I969	II3.6	I06.0	205.4	I94.3	269.8	276.6	3I3.6	306.7	245.2	2I8.6	I26.9	I36.0	25I2.6
I970	(I02.3)	I65.I	204.4	272.I	295.4	265.6	3I9.5	3I0.4	259.I	286.0	I45.I	I44.4	2720.2
I97I	I46.4	I70.0	204.9	2I7.2	236.5	29I.3	285.4	293.9	264.I	25I.I	I59.4	I53.8	2674.I
I972	I52.3	I35.6	2I3.8	268.I	309.0	298.6	289.I	297.8	242.7	I97.I	I9I.2	I77.6	2772.9
I973	I73.7	I8I.6	I86.8	293.2	3I7.7	284.2	339.0	300.6	283.0	235.4	I88.9	I63.4	2947.5
I974	I96.0	I9I.3	224.4	I90.8	26I.5	280.2	3I6.9	324.2	287.3	240.2	I89.0	209.7	293I.5
I975	I73.7	I84.9	2I7.3	242.5	279.I	294.9	355.0	335.7	296.8	262.5	2I2.0	I6I.3	30I5.7

A.M/R.M

-=- L A R A C H E -=-

DUREE DE L'INSOLATION MENSUELLE (en heures et I/IO)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUELLE
1963	98.5	139.2	273.1	268.0	264.0	329.5	347.6	334.1	276.2	261.3	158.1	113.7	2883.2
1964	206.6	138.4	224.8	267.5	316.3	310.1	335.8	326.7	232.1	220.4	169.5	152.8	2903.0
1965	102.7	173.4	209.0	273.0	330.5	308.7	360.0	315.2	251.7	175.4	144.6	97.1	2751.3
1966	136.3	170.4	270.6	285.5	308.0	335.0	315.4	311.1	270.0	199.8	173.2	176.8	2952.1
1967	174.5	156.4	256.9	242.9	306.0	(326.3)	(315.9)	329.3	254.1	219.4	198.2	169.5	(2896.0)
1968	193.9	123.5	183.9	240.2	322.0	304.6	X	X	X	X	X	128.6	1496.7
1969	157.5	98.3	209.2	202.0	276.0	290.8	337.2	325.6	247.3	216.5	150.9	155.2	2666.5
1970	(95.3)	199.6	209.0	290.9	308.3	287.7	350.9	330.2	288.8	240.8	150.3	(172.0)	(2923.8)
1971	128.9	184.9	212.7	219.8	237.7	304.4	315.1	295.5	259.2	261.2	189.8	164.3	2773.5
1972	132.3	107.9	(198.2)	286.9	323.6	304.7	299.4	(311.9)	211.9	(194.6)	177.6	188.4	2717.4
1973	166.8	185.1	192.4	283.8	298.0	(300.1)	319.4	(323.6)	(281.3)	(206.5)	179.8	176.1	2512.9
1974	(150.1)	(187.1)	(211.4)	204.4	260.7	(265.8)	329.2	337.1	287.5	240.9	181.0	234.0	(2879.2)
1975	104.0	178.6	214.7	221.3	272.5	292.6	354.9	350.4	283.5	258.1	215.2	173.0	2998.8

ORIGINAL PAGE IS OF POOR QUALITY

A.M/H.M

-=- M A R R A K E C H -=-

D'REE DE L'INSOLATION MENSUELLE (en heures et I/IO)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUELLE
I955	239.5	2I5.2	265.9	[illegible]	32I.8	295.0	340.3	324.I	3I6.7	XXX	XXX	235.4	(2846.I)
I956	2I3.2	I77.7	240.3	262.4	284.4	357.6	384.2	333.5	293.6	256.I	2I9.9	248.4	328I.3
I957	255.5	235.2	265.2	2I9.4	267.5	349.I	366.6	334.2	286.5	2I4.2	207.I	I64.6	3I66.0
I958	I69.3	I59.8	28I.8	26I.7	3II.9	32I.2	364.6	324.0	287.9	242.7	247.2	I78.8	3I70.9
I959	234.2	2I2.I	236.6	277.2	255.5	33I.2	340.3	347.7	299.7	250.I	227.9	227.8	3240.3
I960	I85.7	237.4	2I9.3	302.2	293.0	266.0	347.7	338.2	295.0	255.5	22I.5	202.3	3I63.6
I96I	2I9.4	266.9	264.7	3I9.4	320.5	304.I	349.6	326.I	270.3	268.5	I96.8	235.3	334I.6
I962	250.0	247.2	2I9.9	256.3	295.7	339.8	355.5	3I3.4	268.5	205.5	2I89.I	229.2	3I60.I
I963	I77.4	I75.6	292.4	270.3	242.5	326.4	354.9	323.9	30I.6	276.0	244.6	I53.3	3I38.9
I964	2I2.0	226.9	252.6	233.2	335.I	297.4	347.I	340.9	244.4	257.8	224.I	I89.3	3I59.8
I965	I95.3	I89.0	250.I	256.8	300.I	322.3	356.2	304.I	276.5	209.3	I96.6	2II.2	3077.5
I966	23I.9	204.4	252.7	3I4.0	284.5	327.I	358.8	338.9	262.5	220.9	I96.5	239.2	323I.7
I967	242.7	I93.4	257.3	205.2	273.2	328.9	337.0	305.9	247.4	239.9	I67.2	233.8	30I2.3
I968	244.I	203.4	I76.6	I85.7	303.6	3I2.8	320.0	305.7	28I.3	276.I	I66.7	I92.9	2976.9
I969	2I0.3	I36.3	205.3	I89.6	268.2	258.5	322.4	340.5	260.8	2II.6	I42.6	2I0.5	2758.8
I970	I6I.4	I85.5	I87.7	294.2	306.6	305.4	345.5	325.7	299.I	238.2	2I3.5	I87.I	3050.9
I97I	2II.9	2II.0	220.6	I9I.7	2I0.5	3I6.6	344.7	3I4.0	282.3	263.6	I9I.2	234.9	2953.0
I972	(223.0)	I88.9	225.7	274.I	290.2	240.4	359.5	335.3	278.5	237.7	22I.3	2I9.3	3I54.0
I973	230.9	207.4	242.2	X	X	328.I	(363.5)	3I5.6	3I0.4	245.4	I93.3	2I3.9	2550.7
I974	27I.7	230.4	225.5	207.2	270.8	304.0	325.7	3I5.9	260.9	264.6	222.7	249.0	3I49.4
I975	2I8.7	205.7	268.I	230.2	264.9	3I2.4	293.3	325.8	2I4.2	279.2	255.2	I8I.6	3069.6

-*- M E K N E S -*-

/S.2

DUREE DE L'INSOLATION MENSUELLE (en Heures et 1/10e)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL
1953	142.9	181.3	242.6	260.3	342.8	296.5	354.4	351.6	265.2	196.1	194.5	159.3	2987.5
1954	157.0	166.1	151.9	205.9	292.0	316.1	402.5	363.4	327.1	273.7	201.4	190.1	3047.2
1955	135.1	135.1	189.3	257.3	309.0	280.9	331.8	328.3	307.3	205.0	156.4	185.0	2820.5
1956	185.1	133.7	190.9	199.1	281.6	337.3	368.6	322.0	277.5	264.3	169.3	195.2	2924.6
1957	185.0	241.2	243.4	190.0	290.5	326.9	361.8	329.6	272.6	201.7	163.1	141.8	2949.6
1958	154.2	178.0	221.2	253.7	290.8	310.3	375.3	327.3	286.6	258.5	189.6	116.5	2962.0
1959	181.2	197.6	195.2	265.1	233.6	326.2	327.2	340.0	264.9	233.0	172.1	144.3	2880.4
1960	164.0	192.5	206.8	290.0	304.2	274.8	361.5	335.2	285.9	224.6	186.6	111.1	2937.2
1961	147.3	247.8	269.5	279.0	305.3	295.0	352.8	342.9	264.2	229.7	138.6	169.4	3041.5
1962	187.9	215.4	187.0	223.1	290.9	320.7	377.4	352.3	272.1	207.1	174.6	150.6	2959.1
1963	126.5	127.1	274.4	261.5	239.9	311.5	384.0	332.5	272.4	204.5	198.5	120.4	2935.3
1964	201.8	211.6	223.5	230.3	352.2	300.4	363.2	343.6	235.4	260.9	193.7	146.8	2063.4
1965	125.0	156.3	222.7	232.0	342.9	327.6	361.7	309.0	236.8	186.7	178.4	161.7	2643.6
1966	195.9	184.0	260.2	265.5	337.7	357.4	352.3	348.6	296.1	221.5	198.8	211.7	3249.7
1967	222.4	191.7	264.5	233.0	268.5	331.5	356.0	344.6	276.9	235.4	152.1	164.2	3070.9
1968	192.2	139.0	165.1	206.0	312.0	319.3	341.8	313.0	301.9	264.6	144.9	149.6	2849.7
1969	178.9	126.5	200.7	192.5	273.6	285.1	368.5	357.2	251.6	226.9	144.5	142.9	2748.9
1970	140.2	216.0	216.2	305.3	306.1	291.2	380.3	325.9	289.4	240.3	179.8	146.9	3038.6
1971	165.1	220.1	230.9	211.1	211.9	307.6	340.3	311.6	274.3	261.7	164.0	171.0	2669.6
1972	154.1	141.7	210.3	278.8	295.1	316.7	346.6	333.8	259.2	214.6	193.1	180.4	2924.4
1973	183.8	209.0	191.2	289.9	307.2	303.6	345.9	335.4	318.8	255.4	204.7	162.7	3107.6
1974	242.9	196.1	197.3	165.1	281.0	296.6	357.8	356.3	282.3	235.2	281.2	209.9	3073.7
1975	183.9	184.0	200.6	209.1	250.3	321.1	362.4	340.9	273.0	283.3	211.3	161.7	2981.6

A.M/H.M

-•- M I D E L T -•-

DUREE DE L'INSOLATION MENSUELLE (en heures et 1/10)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUELLE
1958	204.1	220.7	314.0	318.8	343.9	355.7	361.2	[illegible]	276.3	264.5	191.4	196.2	3350.7
1959	247.2	194.9	285.9	337.8	308.9	353.9	299.3	312.0	285.5	281.9	253.6	245.4	3416.3
1960	207.1	271.9	289.1	313.8	309.0	275.4	305.3	294.1	309.4	285.8	240.0	180.9	3281.8
1961	219.6	267.9	251.0	313.8	287.5	294.2	301.0	321.6	264.0	273.5	192.6	234.1	3220.8
1962	236.8	244.0	230.4	303.1	292.7	304.7	355.9	290.0	256.5	207.4	219.6	228.8	3169.9
1963	197.5	238.4	291.8	240.8	253.1	322.7	335.7	301.0	308.7	304.1	256.4	192.5	3242.7
1964	160.8	126.9	287.4	283.2	317.7	321.3	322.4	314.7	226.6	283.4	210.5	207.8	3070.7
1965	183.5	185.1	246.4	265.1	304.0	308.2	280.4	246.0	262.4	201.9	207.5	230.3	2922.8
1966	244.7	246.7	253.2	320.2	298.0	302.8	346.1	314.6	(249.0)	262.5	200.7	256.8	3295.3
1967	256.2	(185.1)	286.4	(262.6)	263.1	287.6	293.2	282.2	244.6	252.1	161.2	197.5	(3011.8)
1968	(240.8)	(209.6)	234.7	253.4	297.0	325.4	278.5	XXX	XXX	XXX	160.9	219.7	2220.0
1969	228.5	165.3	232.2	234.8	308.4	282.7	312.6	304.8	270.2	195.3	165.9	212.1	2932.8
1970	188.0	231.7	253.5	308.4	309.6	300.4	359.5	279.7	255.6	248.6	192.2	191.5	3116.7
1971	224.4	223.1	245.0	267.2	283.9	304.6	336.8	280.9	279.6	243.4	(211.1)	216.1	(3118.1)
1972	236.8	220.1	263.8	(303.3)	(293.4)	246.6	358.5	332.6	304.8	(287.3)	218.1	235.3	(3394.5)
1973	233.2	206.1	236.2	277.6	330.2	305.2	334.8	289.6	319.5	263.1	212.1	229.6	3237.6
1974	281.9	247.9	256.4	239.6	305.9	304.2	311.4	295.0	269.8	283.2	253.1	247.3	3295.7
1975	229.1	210.0	307.8	213.5	313.6	350.6	312.6	326.1	266.1	303.8	250.7	197.7	3284.3

A.M/H.M

— M I D E L T —

DUREE DE L'INSOLATION MENSUELLE (en heures et 1/10)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUELLE
1958	204.1	220.7	314.0	318.8	343.9	355.7	361.2	303.9	276.3	264.5	191.4	196.2	3350.7
1959	247.2	194.9	285.9	337.8	308.9	353.9	299.3	312.0	285.5	281.9	253.6	245.4	3416.3
1960	207.1	271.9	289.1	313.8	309.0	275.4	305.3	294.1	309.4	285.8	240.0	180.9	3281.8
1961	219.6	267.9	251.0	313.8	287.5	294.2	301.0	321.6	264.0	273.5	192.6	234.1	3220.8
1962	236.8	244.0	230.4	303.1	292.7	304.7	355.9	290.0	256.5	207.4	219.6	228.8	3169.9
1963	197.5	238.4	291.8	240.8	253.1	322.7	335.7	301.0	308.7	306.1	256.4	192.5	3242.7
1964	160.8	126.9	287.4	283.2	317.7	321.3	322.4	314.7	226.6	283.4	218.5	207.8	3070.7
1965	183.5	185.1	246.4	265.1	304.0	308.2	280.4	248.0	262.4	201.9	207.5	230.3	2922.8
1966	244.7	246.7	253.2	320.2	298.0	302.8	346.1	314.6	(249.0)	262.5	200.7	256.8	3295.3
1967	256.2	(185.1)	286.4	(262.6)	283.1	287.6	293.2	282.2	244.6	252.1	161.2	197.5	(3011.8)
1968	(240.8)	(209.6)	234.7	253.4	297.0	325.4	278.5	XXX	XXX	XXX	160.9	219.7	2220.0
1969	228.5	165.3	232.2	234.8	306.4	282.7	312.6	304.8	270.2	195.3	165.9	212.1	2932.8
1970	188.0	231.7	253.5	306.4	309.6	300.4	359.5	279.7	255.6	248.6	192.2	191.5	3116.7
1971	224.4	223.1	245.0	267.2	283.9	304.6	336.8	280.9	279.6	243.4	(211.1)	216.1	(3118.1)
1972	236.8	220.1	263.8	(303.3)	(293.4)	246.6	358.5	332.6	304.8	(287.3)	218.1	235.3	(3394.5)
1973	233.2	206.1	236.2	277.6	330.2	305.2	334.8	289.6	319.5	263.1	212.1	229.6	3237.6
1974	281.9	247.9	256.4	239.6	305.9	304.2	311.4	295.0	269.6	283.2	253.1	247.3	3295.7
1975	229.[illegible]	210.0	307.8	213.5	313.6	350.6	312.6	328.1	266.1	303.8	250.7	197.7	3264.3

ORIGINAL PAGE IS
OF POOR QUALITY

A.M/H.M

-- O U A R Z A Z A T E --

DUREE MENSUELLE DE L'INSOLATION (en heures et I/I0)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE
[illegible]957	X	2I0.2	2[illegible]	3I0.0	352.[illegible]	3[illegible]	327.6	2[illegible]5.4	2[illegible]2.[illegible]	[illegible]	224.9	I67.I
I95[illegible]	2I4.0	I62.4	257.4	300.[illegible]	333.[illegible]	[illegible]	355.7	279.6	252.0	246.[illegible]	223.I	227.7
[illegible]	22[illegible].5	243.9	2[illegible]3.4	324.0	36[illegible].3	35[illegible]	26I.2	267.7	2[illegible]4.4	276.7	25I.3	25[illegible].4
I960	23I.7	26I.3	29I.5	2[illegible]6.5	355.5	[illegible]	[illegible]4.4	2[illegible]0.0	2[illegible]6.5	277.7	253.0	235.6
I96I	240.6	24[illegible].2	240.4	307.7	3[illegible].2	353.4	2[illegible]0.5	2[illegible]3.5	244.I	252.7	[illegible].2	232.7
I962	255.7	2[illegible]0.4	[illegible]	3I[illegible].9	3I2.[illegible]	347.3	3I9.7	276.5	2[illegible]5.9	2I9.6	[illegible].9	234.7
I963	223.5	255.4	335.I	3[illegible].7	337.I	377.2	348.6	3I4.8	3I6.9	295.9	272.5	246.0
I964	I72.4	267.I	3I2.5	32I.2	324.9	335.I	25I.9	307.9	2[illegible]4.5	277.3	257.3	23I.6
I965	2I5.I	I[illegible]4.3	2[illegible]3.5	305.7	299.2	25[illegible].0	2[illegible]2.2	27I.4	3[illegible]3.4	2I3.2	234.5	26[illegible].6
I966	269.[illegible]	25I.I	272.7	3I6.5	279.4	23[illegible].4	266.6	29I.0	237.3	[illegible]79.2	24I.2	249.9
I967	262.[illegible]	222.9	2[illegible]4.[illegible]	30I.7	309.9	23[illegible].6	270.7	259.7	22[illegible].0	27I.7	I59.5	I[illegible]7.2
I96[illegible]	I43.2	230.[illegible]	2[illegible]0.0	303.2	309.0	X	224.6	263.2	2[illegible]6.6	279.6	227.[illegible]	I77.4
I969	X	I60.6	266.9	292.[illegible]	X	X	X	2[illegible]6.[illegible]	254.7	252.2	(20I.6)	(24I.2)
I970	24I.I	236.0	262.4	323.9	305.0	(320.2)	320.3	262.[illegible]	23[illegible].3	237.9	I[illegible]9.I	2I9.3
I97I	2[illegible]4.6	233.2	2[illegible]6.4	3I[illegible].9	3[illegible]I.4	35[illegible].5	346.4	290.0	262.2	25I.[illegible]	232.3	233.5
I972	290.4	25[illegible].9	3II.6	305.7	[illegible]	X	(367.4)	3I5.4	302.3	249.3	266.2	24[illegible].7
I973	275.0	257.7	306.3	306.I	325.7	32[illegible].0	333.6	26I.2	304.[illegible]	293.[illegible]	202.0	275.0
I974	3II.8	293.0	305.6	333.3	32[illegible].7	334.2	307.3	307.5	2[illegible]0.0	32I.0	256.6	259.0
I975	237.5	250.[illegible]	33[illegible].7	324.I	34[illegible]	375.6	30I.9	3[illegible]6.0	256.8	300.0	272.0	2I0.I

A.M/H.M

-=- O U J D A - L E S - A N G A D -=-

DUREE DE L'INSOLATION MENSUELLE
(en heures et I/I0)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUELLE
I955	I56.0	I88.8	209.7	27I.5	32I.5	297.I	340.4	327.4	295.9	234.I	I68.3	I95.3	3006.0
I956	I96.0	I53.3	2I9.5	224.9	294.3	349.2	386.0	340.0	293.0	246.5	208.3	233.6	3I44.9
I957	2I6.6	240.3	234.5	236.7	3II.6	366.4	398.7	343.0	309.I	227.9	I77.9	I86.2	3248.9
I958	I6I.6	2I0.6	252.9	300.6	335.7	356.4	405.0	36I.4	3I5.I	243.6	I78.4	I55.4	3286.7
I959	207.6	I69.8	237.I	336.3	282.I	343.6	380.9	332.2	289.8	242.5	I89.7	I80.I	3I9I.7
I960	I67.5	I97.7	209.I	285.8	289.3	3I7.3	384.2	353.I	339.9	265.6	207.5	I55.9	3I72.9
I96I	20I.6	23I.6	247.8	3I4.I	344.8	294.3	345.2	339.5	265.7	263.9	I97.8	202.2	3248.5
I962	204.4	2I5.8	I80.I	260.4	290.3	270.I	394.4	367.8	277.0	236.8	I84.3	I59.8	306I.2
I963	II3.2	I42.2	273.I	235.4	242.3	293.8	363.3	340.8	275.3	3I0.6	234.0	I39.I	2963.I
I964	I8I.6	202.8	232.2	258.0	367.8	340.5	382.I	357.I	255.4	270.9	234.0	I56.I	3238.5
I965	I44.3	I72.7	2I2.0	254.2	359.2	344.7	32I.5	3I2.5	27I.3	I85.3	I86.0	2I3.8	2977.6
I966	I99.9	225.0	272.6	278.4	300.9	3I6.0	360.4	348.4	272.6	224.3	I86.4	232.8	32I7.7
I967	232.3	I05.2	27I.I	222.I	295.7	283.6	36I.0	(322.3)	270.2	267.7	I65.6	I60.0	3036.8
I968	257.2	I66.9	I84.I	230.7	299.9	34I.2	34I.7	3I4.6	295.6	264.9	I78.2	I3I.9	3046.9
I969	I98.0	I24.7	200.8	(2I5.8)	282.2	329.4	347.3	326.2	264.8	I88.5	I55.9	I79.8	288I.4
I970	I33.5	232.8	I83.9	289.6	293.7	3I5.6	377.9	304.6	269.8	246.6	2I7.3	I78.2	3043.5
I97I	(I74.6)	254.0	2I2.6	202.7	240.3	327.3	334.0	283.3	267.6	260.6	I90.5	I59.4	2906.9
I972	I67.0	I46.2	205.6	258.2	279.2	(32I.0)	370.0	292.4	220.6	200.4	I72.4	I94.0	2835.0
I973	I95.6	I99.4	I6I.8	236.6	277.3	256.I	(294.I)	278.9	270.7	24I.7	I62.4	I52.2	(2726.8)
I974	249.0	I57.4	I95.2	225.I	300.5	267.9	326.7	340.5	279.I	249.5	224.5	259.I	3074.5
I975	I95.3	I80.0	233.6	(I35.4)	247.5	332.7	333.0	325.8	254.I	277.I	2I6.I	I85.3	29I5.9
I976	234.0	I72.4	230.4	224.3	230.2	32I.7	320.3	209.I	248.7	2I2.4	I98.I	I5I.9	2833.5

A.M/H.M

— R A B A T - S A L E —

DUREE DE L'INSOLATION MENSUELLE (en heures et 1/10)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUELLE
1955	138.4	151.1	190.7	260.8	319.3	295.9	314.5	305.8	295.3	229.4	161.8	202.9	2865.9
1956	185.7	135.8	(198.5)	234.4	329.4	341.7	381.2	327.7	251.5	272.8	202.3	235.2	(3096.2)
1957	225.9	228.5	243.5	242.2	280.4	349.9	364.4	337.3	271.7	230.4	205.7	171.8	3151.7
1958	177.2	166.3	234.4	249.4	304.5	286.3	385.1	333.4	286.0	282.8	206.2	126.6	3038.2
1959	209.6	195.7	199.1	275.5	271.0	312.5	292.3	314.8	304.0	258.1	186.9	170.7	2990.2
1960	151.9	194.3	216.9	316.2	311.8	269.5	350.1	370.4	287.1	206.5	204.3	128.6	3007.6
1961	146.3	239.6	275.3	260.5	294.3	267.9	327.5	320.0	251.4	235.3	138.3	181.4	2937.8
1962	182.2	237.7	176.8	260.0	271.0	285.1	325.8	307.9	294.0	207.1	190.6	146.9	2805.1
1963	101.1	133.7	275.0	268.9	262.0	274.1	331.4	282.3	263.9	246.6	172.5	123.8	2735.3
1964	194.3	178.5	196.6	241.2	303.2	298.6	309.6	307.2	204.7	224.4	163.8	X	2623.5
1965	111.6	163.4	189.6	249.0	327.2	305.9	342.2	290.9	230.5	175.3	172.9	157.0	2715.5
1966	174.0	190.4	255.9	293.0	299.7	316.4	306.6	315.3	280.4	207.2	202.8	222.4	3064.1
1967	219.2	181.8	237.4	234.2	292.3	318.3	312.7	324.6	260.0	219.3	163.7	164.0	2957.5
1968	206.3	156.2	188.0	248.0	310.8	312.6	320.0	252.5	277.3	248.7	157.6	143.6	2861.6
1969	142.2	116.0	204.7	202.8	292.7	290.1	296.1	312.2	251.9	237.4	149.6	162.2	2657.9
1970	134.2	204.8	206.3	280.6	290.0	245.4	325.6	322.1	258.1	224.3	166.5	164.7	2824.6
1971	(160.3)	(195.8)	(216.0)	(216.7)	(234.2)	(292.3)	(282.6)	(269.7)	(266.4)	(243.4)	(161.8)	(170.0)	(2709.2)
1972	(156.4)	(150.6)	(197.3)	(256.5)	(297.9)	(201.5)	(214.0)	283.3)	(222.2)	(203.7)	(205.5)	(188.9)	(2727.8)
1973	(190.5)	(191.4)	(173.0)	(272.2)	(296.4)	(267.0)	(312.6)	(289.2)	(260.1)	(235.1)	(190.1)	(169.3)	(2866.9)
1974	(218.0)	(199.1)	(205.0)	(189.6)	(260.6)	(265.1)	(294.0)	(320.4)	(271.5)	(245.2)	(189.8)	(228.4)	(2886.7)
1975	(180.9)	(182.9)	(211.3)	(264.5)	(261.7)	(271.0)	323.2	324.5	285.9	264.5	216.4	161.2	2928.1

ORIGINAL PAGE IS OF POOR QUALITY

A.M/M.M

-•- S A P I - A E R O -•-

DUREE DE L'INSOLATION MENSUELLE
(en HEURES et 1/10)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL ANNUELLE
1955	X	188.4	231.6	292.7	346.7	308.3	311.2	303.7	279.9	216.0	159.6	212.9	2851.0
1956	193.9	146.3	219.1	267.9	307.8	311.6	367.5	340.2	254.6	241.7	155.7	206.7	3093.1
1957	218.8	229.6	253.4	253.9	316.8	356.1	337.1	270.7	228.7	221.5	191.4	161.2	3039.2
1958	145.7	151.0	277.4	286.6	318.4	300.8	366.4	345.4	300.8	235.8	229.2	147.7	3107.2
1959	209.1	223.3	256.2	295.6	313.7	308.8	276.4	316.9	269.4	218.5	177.9	157.9	3028.0
1960	154.8	197.3	215.4	285.0	266.5	252.0	323.1	304.0	257.6	261.6	216.1	166.5	2930.3
1961	206.6	237.6	274.8	304.4	295.6	282.4	341.0	338.2	265.2	256.7	161.5	196.0	3162.2
1962	226.2	250.3	227.3	227.5	303.7	251.0	329.4	312.2	270.5	204.0	182.2	182.1	3006.5
1963	131.7	161.5	288.7	271.4	253.5	287.7	312.2	307.3	259.2	291.5	217.5	126.6	2929.2
1964	210.4	237.2	251.9	250.5	314.8	280.1	333.5	317.6	253.1	252.3	208.2	190.4	3110.0
1965	165.4	179.1	266.3	295.5	248.8	334.4	364.6	339.5	266.6	213.1	200.3	219.9	3215.1
1966	207.4	220.7	272.2	335.8	291.5	323.5	327.5	357.4	116.6	245.6	200.4	223.3	3123.3
1967	232.6	220.5	275.3	293.5	324.4	343.5	(357.7)	332.2	273.9	252.4	146.6	203.3	(3245.3)
1968	240.6	183.3	254.5	234.7	321.1	310.8	327.6	304.2	304.8	269.7	184.2	196.2	3100.7
1969	186.8	153.3	238.5	251.6	325.4	302.5	319.7	331.5	278.6	250.2	158.0	160.1	2915.7
1970	150.6	215.5	245.6	317.7	313.8	314.2	351.7	335.5	281.5	223.0	191.4	128.3	3079.0
1971	157.6	219.2	255.9	263.3	302.4	350.2	333.1	356.6	257.1	282.3	173.6	220.4	3251.5
1972	112.4	215.5	251.1	277.6	359.1	X	(353.7)	330.6	257.3	240.8	231.5	154.5	2975.7
1973	154.5	234.7	276.2	327.6	332.5	345.4	397.1	290.4	312.0	253.5	206.3	(200.0)	(3336.6)
1974	(244.9)	219.9	229.5	249.1	234.2	(287.8)	288.3	332.2	281.3	279.5	235.2	232.1	(3175.1)
1975	213.9	215.6	275.3	298.2	314.5	288.9	335.5	330.5	295.0	283.8	259.1	155.4	3244.3

METEOROLOGIE NATIONALE

Date :

— S I D I - I F N I —

Fraction d'Insolation (en %)

HOURS OF SUNSHINE/MONTH

STATIONS	Altitude en mètres	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	Moyenne ANNEE
1974		x	x	x	x	28	45	34	x	x	25	33	70	
1975		64	60	71	51	61	49	62	49	60	69	82	57	61
1976		75	69	68	61	34	19	33	70	79	69	72	59	59
1977		65	62	73	63	50	54	41	38	48	67	65	52	57
1978		59	54	68	60	57	43	48	30	60	67	71	61	57
1979		56	76	66	66	52	29	44	31	54	67	76	75	58
Durée de l'Insolation (en heures et 1/10)														
1974		x	x	x	x	(118.8)	187.5	(151.4)	178.8	(190.4)	(244.0)	211.3	223.6	
1975		206.3	222.1	263.0	(187.9)	256.3	207.2	266.3	200.8	224.5	246.2	255.6	182.7	(226.6)
1976		242.4	216.1	251.0	234.5	142.8	78.1	139.7	285.7	290.7	246.0	225.5	187.6	211.7
1977		201.7	192.3	270.2	243.5	211.0	226.1	174.3	158.2	176.6	237.5	201.4	164.2	204.9
1978		191.4	169.7	251.1	230.4	236.1	179.6	206.5	121.8	221.8	239.8	220.9	192.7	205.3
1979		180.2	235.9	245.6	253.6	218.3	121.4	189.5	125.5	199.4	239.7	237.6	238.9	206.3
Températures Minimales Moyennes Mensuelles au Sol (en °C)														
1974		x	x	x	x	(14.1)	(16.0)	(17.5)	(16.9)	(16.0)	(12.8)	(10.3)	(08.7)	x
1975		10.2	10.2	09.9	12.4	13.9	18.4	x	x	x	15.2	12.3	11.8	x
1976		09.7	11.7	13.0	13.2	15.1	16.7	18.7	20.6	17.6	15.5	12.5	13.2	14.8
1977		12.0	11.4	14.4	13.7	14.8	15.7	16.8	16.7	17.8	15.9	13.3	13.7	14.7
1978		11.6	11.9	12.2	12.9	14.5	16.3	17.3	17.2	18.4	17.1	16.1	14.1	15.0

Imp. Météo. Nle. Casa. N° 218 ter.

ORIGINAL PAGE IS OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY

/ MA

- TANGER -

- Durée de l' Insolation Mensuelle (en Heures et 1/10 è)

HOURS OF SUNSHINE/MONTH

ANNEE	JANVIER	FEVRIER	MARS	AVRIL	M A I	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	MOYENNE ANNEE
1955	114.8	148.7	204.2	318.1	348.2	330.0	319.3	346.3	318.1	221.9	142.1	X	(255.6)
1956	153.9	151.9	183.2	226.0	323.2	316.8	393.1	337.8	283.1	269.8	182.6	202.3	252.4
1957	225.2	196.6	230.9	208.1	259.6	344.5	359.2	366.2	271.2	216.8	194.3	139.5	254.3
1958	165.0	174.9	236.4	260.9	312.0	316.0	381.5	320.3	290.3	272.4	204.1	101.8	253.0
1959	162.9	174.2	175.9	254.4	244.5	336.9	342.9	349.5	290.0	240.4	154.4	137.0	238.6
1960	155.0	149.9	182.6	278.7	323.3	311.0	357.4	350.1	289.5	205.2	155.5	133.0	240.9
1961	138.7	202.6	277.0	263.8	299.0	321.6	352.4	341.1	261.3	256.5	128.8	145.8	249.1
1962	180.6	213.4	140.6	263.6	291.8	329.1	365.9	352.6	293.3	202.1	170.9	126.6	244.2
1963	86.2	117.8	231.1	249.1	275.0	309.5	387.3	354.5	304.6	283.4	178.1	119.8	241.4
1964	208.7	120.7	215.9	283.9	341.1	311.9	364.7	341.6	241.7	253.4	181.8	155.8	251.7
1965	124.0	(177.2)	212.1	297.0	345.2	326.5	374.5	336.0	272.9	180.4	139.3	127.6	(242.7)
1966	138.7	174.6	288.6	266.2	334.0	346.7	352.7	349.4	292.4	235.1	187.1	194.9	263.4
1967	173.9	156.1	278.8	244.1	321.3	325.9	354.1	349.9	281.0	245.7	148.9	188.5	255.7
1968	216.4	125.1	175.7	255.4	338.8	317.7	361.2	338.6	301.2	253.3	162.2	150.3	249.7
1969	159.8	97.1	194.8	233.7	250.2	317.0	373.5	360.2	257.4	237.2	139.7	178.7	234.1
1970	103.2	212.1	230.6	288.8	323.7	306.1	374.5	347.8	312.1	252.1	181.4	201.9	261.2
1971	133.0	203.2	237.3	239.1	237.7	320.1	361.0	336.4	290.2	269.4	196.9	166.1	249.2
1972	157.2	121.1	190.0	293.0	360.8	X	(362.3)	361.5	(247.5)	(197.0)	184.2	187.4	(242.0)
1973	193.5	190.7	195.8	284.0	314.4	334.0	325.8	354.8	309.0	232.4	180.5	185.9	259.1
1974	200.2	207.9	218.9	214.2	295.7	267.5	364.6	360.4	312.3	251.4	195.7	226.5	259.6
1975	108.1	165.8	205.2	207.0	262.5	293.1	374.6	352.8	288.4	283.9	221.1	161.3	250.3

METEOROLOGIE NATIONALE

— T A N - T A N —

Durée de l'insolation mensuelle (en heures et 1/10)

HOURS OF SUNSHINE/MONTH

Date :

ANNEES	Altitude en mètres	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	Moyenne ANNEE
1978		x	x	x	250.3	247.7	179.7	233.8	153.0	218.8	246.7	214.0	199.3	
1979		176.8	235.6	228.0	168.5	193.4	121.3	135.3	152.4	201.0	228.8	169.1	212.7	185.2
1980		210.9	218.6	244.6	261.4	211.7	165.8	173.5	196.3					

Imp. Météo. Nle. Casa. N° 218 (e).

/ M.

- T A Z A -

- Durée de l' Insolation Mensuelle (en Heures et I/IC à)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	M A I	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	MOYENNE ANNEE
1960	157.5	185.6	193.9	291.5	317.6	290.4	350.8	335.0	312.5	228.8	193.5	121.5	248.2
1961	178.7	225.1	247.9	282.2	288.3	269.7	340.6	342.0	261.4	251.3	158.2	179.2	252.1
1962	194.3	205.6	159.3	252.6	297.3	295.7	365.7	344.8	273.8	204.2	168.8	161.0	243.6
1963	120.5	143.0	278.2	261.0	251.6	350.4	370.2	329.4	305.1	295.7	215.2	125.4	253.8
1964	181.7	187.7	239.2	226.1	362.4	331.0	361.7	351.4	254.2	274.8	189.2	179.5	262.[illegible]
1965	151.9	163.1	230.7	248.1	356.9	322.3	350.0	312.2	261.4	205.2	182.9	205.5	249.2
1966	215.8	213.4	271.8	279.9	322.6	317.0	344.4	346.0	296.5	245.5	218.8	242.4	276.2
1967	(239.2)	185.1	278.9	255.8	279.8	(321.0)	365.6	(351.9)	305.3	264.0	201.3	203.2	270.9
1968	250.5	172.3	191.3	241.7	289.7	354.2	X	X	X	X	172.9	190.9	(232.9)
1969	185.9	129.3	(218.1)	235.6	285.0	318.2	386.9	357.5	298.9	240.3	(159.2)	171.0	(248.8)
1970	(153.4)	232.8	(219.6)	306.8	(326.4)	324.6	390.5	331.8	296.5	267.1	222.6	175.3	270.6
1971	183.0	225.7	(215.1)	235.7	261.7	318.7	350.7	(318.1)	282.2	270.2	181.4	193.1	253.0
1972	179.6	163.9	(255.7)	(294.2)	(307.3)	(293.4)	(287.1)	339.3	(297.7)	156.2	(196.2)	(224.4)	(257.9)
1973	(215.5)	(226.1)	(207.4)	(267.0)	(343.2)	321.6	344.0	314.[illegible]	(326.3)	(256.9)	183.2	180.8	(265.5)
1974	263.0	(205.7)	(211.8)	188.2	311.8	289.3	353.7	346.5	299.2	247.2	225.1	233.4	(264.4)
1975	192.6	176.6	(232.6)	(164.8)	(25[illegible])	331.8	345.1	317.2	(250.1)	263.2	(210.9)	172.2	(242.7)

ORIGINAL PAGE IS
OF POOR QUALITY

/SZ

-=- T E T O A N-A E R O -=-

DUREE DE L'INSOLATION MENSUELLE (en heures et I/I0)

HOURS OF SUNSHINE/MONTH

STATION	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	TOTAL
I963	7I.9	I37.2	2I4.9	2I0.2	246.I	3I7.3	289.6	272.9	247.9	2I4.0	I7I.3	II5.7	2509.0
I964	I45.9	I30.2	225.7	232.I	29I.7	255.6	29I.2	295.3	II6.8	202.4	I58.6	I68.I	25I3.6
I965	I42.2	I63.5	I67.I	28I.5	344.5	3I7.0	356.6	305.4	202.0	II2.4	I74.8	I88.7	2755.7
I966	I65.I	I67.2	240.6	259.9	248.I	3I4.9	290.5	304.2	220.2	223.4	209.5	206.9	2850.5
I967	I94.4	I32.9	205.I	I99.4	272.4	244.5	323.3	30I.4	233.2	2I4.7	I32.3	I94.0	2647.6
I968	(2I7.3)	II3.I	I27.8	I70.I	307.3	287.4	30I.9	306.8	262.2	I84.6	I00.4	I6I.9	2540.8
I969	(I2I.9)	5I.5	I63.7	(2II.2)	(2I6.5)	(276.8)	276.4	277.3	I95.9	272.0	I28.4	I78.7	2270.3
I970	I09.3	29.3	I67.4	248.5	268.I	265.5	3I3.7	300.3	I95.I	I97.6	I28.I	I73.5	2586.4
I97I	(I49.6)	(I96.5)	(I75.8)	(I88.9)	(23I.5)	(297.4)	(305.2)	285.3	(234.6)	X	X	X	X
I972	X	X	X	X	X	X	X	X	X	X	I80.4	I93.I	X
I973	(2I6.6)	(200.5)	I45.0	250.7	(25I.9)	(308.6)	(294.9)	(283.I)	289.4	(208.I)	I20.9	(I72.7)	(2742.4)
I974	(20I.4)	I97.9	(233.9)	(2I2.8)	30I.4	246.3	(297.0)	(306.8)	300.4	(246.2)	(2I0.5)	(207.9)	(2962.5)
I975	(I98.I)	(I50.3)	(207.8)	(I7I.I)	(249.I)	(338.3)	(347.9)	(3I5.0)	(260.8)	(2I3.I)	(2I0.7)	(I47.3)	(2809.5)

ORIGINAL PAGE IS
OF POOR QUALITY

/ MA

- A G A D I R -

Durée de l' Insolation Mensuelles (en Heures et 1/10 è)

HOURS OF SUNSHINE/MONTH

ANNEES	JANVIER	FEVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPTEMBRE	OCTOBRE	NOVEMBRE	DECEMBRE	MOYENNE
1955	262.6	249.0	324.1	323.1	312.7	307.5	320.4	299.5	274.3	233.1	170.5	270.0	270.9
1956	242.2	188.9	305.2	300.2	321.4	279.5	295.0	280.0	275.9	251.7	230.7	250.4	259.2
1957	291.5	256.3	290.7	319.1	303.6	340.3	321.7	246.6	223.1	234.4	233.4	192.5	271.9
1958	200.0	121.6	275.9	302.9	306.9	275.7	270.6	282.9	216.4	250.3	251.5	199.5	252.9
1959	244.1	255.8	247.3	245.9	307.0	272.1	272.4	283.6	207.9	256.2	235.1	240.0	255.7
1960	228.3	237.0	279.5	291.9	295.5	246.1	258.2	250.1	212.6	237.2	245.4	246.5	252.4
1961	252.0	255.4	275.6	306.4	316.7	307.9	284.5	268.6	256.7	245.9	218.7	243.0	269.4
1962	247.4	260.0	251.6	265.2	321.3	278.4	310.8	288.5	277.7	224.5	225.4	206.0	263.9
1963	174.1	207.1	319.8	275.6	294.6	295.9	291.3	219.8	286.2	266.1	240.9	165.9	253.1
1964	229.0	252.3	252.1	276.6	259.9	294.4	295.8	214.4	240.3	249.5	232.0	216.7	251.9
1965	210.7	208.5	274.0	284.7	294.1	274.3	279.9	278.4	261.9	234.7	228.4	251.1	257.4
1966	245.2	227.8	291.9	337.1	269.6	300.5	257.5	278.6	245.7	287.5	227.0	255.3	260.9
1967	261.7	245.7	283.2	272.2	320.1	277.9	289.3	262.1	242.0	242.3	189.9	263.4	262.5
1968	255.6	213.5	262.4	255.0	310.4	267.9	281.5	253.7	246.0	254.7	205.2	226.6	255.4
1969	195.8	157.9	258.2	292.4	306.6	245.5	275.3	209.6	281.7	263.0	131.0	226.3	242.0
1970	182.7	1[illegible].5	256.7	311.5	311.2	291.0	259.9	292.2	207.3	242.7	180.5	192.1	243.0
1971	233.3	221.[illegible]	266.4	259.0	327.2	245.6	269.7	299.8	241.6	235.2	202.4	251.7	254.9
1972	262.7	234.2	273.6	280.5	357.1	203.1	(282.3)	261.8	256.4	242.1	258.4	242.5	263.3
1973	258.1	251.2	279.7	316.7	321.3	290.6	280.1	256.3	280.9	233.7	225.0	237.7	269.3
1974	292.1	260.5	253.5	288.9	283.1	281.5	245.0	256.8	244.5	291.7	222.7	256.3	260.8
1975	213.5	243.4	297.6	300.7	326.9	282.4	313.1	252.5	255.8	245.2	274.1	170.3	264.6

APPENDIX F

BIBLIOGRAPHY

APPENDIX F: BIBLIOGRAPHY

1. "Annual Report: 1979," Banque Morocaine du Commerce Exterieure, Casablanca, Morocco, June, 1980.

2. "A New Technology for Small-scale Irrigation in Pakistan: Economics of Solar-Powered Micro-Pumps for Irrigation," Intermediate Technology Industrial Services.

3. "Foreign Economic Trends and their Implications for the United States--Morocco," International Marketing Information Series, FET 81-022, U.S. Dept. of Commerce, Washington, D.C., February, 1981.

4. "Home Electric Power Systems" and "AC Power Systems," ARCO Solar, Inc.

5. Le Maroc en Chiffres: 1979, Secretariat d'Etat au Plan et au Developpement Regional, Direction de la Statistique, Rabat, Morocco, 1980.

6. "Memorandum on Morocco's Agricultural Sector: Identification of Issues and Bank Strategy," World Bank, Report No. 2667a-MOR, Washington, D.C., May, 1980.

7. "Monthly Information Review," Banque Morocaine du Commerce Exterieure, Nos. 29, 30, 31, 32, 33, 34, Casablanca, Morocco, July 1980-April, 1981.

8. Morocco: A Country Study, Area Handbook Series, American University, Washington, D.C., 1978.

9. "Morocco: Agricultural Situation," Attache Report MO-1006, U.S. Embassy, Rabat, Morocco, February 1981.

10. Morocco: Basic Economic Report, vols. I and II, World Bank, Report No. 3289-MOR, Washington, D.C., Dec. 1980.

11. "Morocco: Country Development Strategy Statement, FY 83," U.S. Agency for International Development, Washington, D.C., February, 1981.

12. "1980 Photovoltaic Systems Development Program Summary Document," (draft) Jet Propulsion Laboratory, Pasadena.

13. Projet d'Alimentation en Eau Potable dans le Milieu Rural, Kingdom of Morocco, Ministry of Interior, Rabat, Morocco, 1980.

14. Rapport d'Activite: 1979, Office National de l'Ectricite, Casablanca Morocco, 1980.

15. "Renewable Energy Development Project, Morocco--Phase I,' Charles T. Main Consultants, USAID/Ministry of Energy and Mines, Rabat, Morocco, December, 1980.

16. "The Economics of Renewable Energy Systems for Developing Countries," David French, January, 1979.